

Sustaining Volunteer Enlistments in the Decade Ahead: the Effect of Declining Population and Unemployment

Final Report

By

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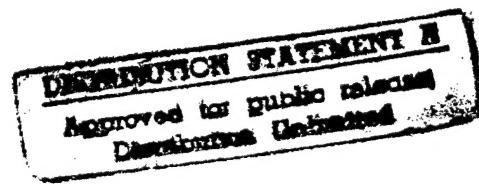
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Contract No. MDA903-75-C-0204

September 1977

OPERATIONS ANALYSIS GROUP



19970506 126

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Prepared For:

The Assistant Secretary of Defense
(Manpower, Reserve Affairs and Logistics)

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Sustaining Volunteer Enlistments in the Decade Ahead: The Effect of Declining Population and Unemployment		5. TYPE OF REPORT & PERIOD COVERED CR 11/76-9/77
7. AUTHOR(s) Daniel F. Huck Jerry Allen		6. PERFORMING ORG. REPORT NUMBER MDA903-75-C-0204
9. PERFORMING ORGANIZATION NAME AND ADDRESS General Research Corporation 7655 Old Springhouse Road McLean, Va. 22102		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS The Assistant Secretary of Defense (M, RA&L) The Pentagon		12. REPORT DATE September 1977
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		13. NUMBER OF PAGES 110
		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) All-volunteer force, manpower planning, forecasting, quality enlistments, nonlinear regression analysis, econometric modeling		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The study was prompted by concern that the AVF faces serious manpower problems over the next decade. Specifically, four issues were addressed in the study: o What effect, if any, will the projected decline in the youth population (17-21-year-old) have on quality enlistments over the next decade?		
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Chapter 1

EXECUTIVE SUMMARY

OBJECTIVES OF THE STUDY

This report was prepared for the Office Assistant Secretary of Defense, Manpower, Reserve Affairs & Logistics. The study was prompted by concern that the AVF faces serious manpower supply problems over the next decade. Specifically, four issues were addressed in the study:

- What effect, if any, will the projected decline in the youth population (17-21-year-old) have on quality enlistments over the next decade?
- What will be the effect on the supply of quality enlistments if the economy continues to improve and the unemployment rate continues to decline?
- If the decline in quality enlistments is projected over the next decade, what additional recruiting resources will be required to offset this decline?
- What are the manpower-policy implications of attempting to sustain the AVF in the face of potential shortages of quality volunteers?

METHODOLOGY EMPLOYED

The analysis consists principally of the development of an econometric model that relates numbers of accessions to several "explanatory" variables that are hypothesized to affect numbers of accessions. These relationships are then used to estimate future accession levels once future values of the explanatory variables have been projected or hypothesized. Finally, a sensitivity calculation is made to show how future accession levels can be affected by changes in those explanatory variables under the control of the Services.

Selection of the Variables to be Included in the Model

Based upon a host of other studies that have attempted to forecast enlistment supply and the desirability of empirically testing the effect of population on enlistments, the following five variables are included in the model.

- Quality enlistments. The dependent variable used in this analysis is the number of non-prior-service, male, diploma high-school graduates (DHSG) in the upper 50th percentile of the standardized mental test score distribution (mental categories I-IIIA). A fundamental assumption of the analysis and the rationale for the selection of this dependent variable is that this group is "supply-limited;" that is, the number of quality accessions is limited by the supply of such persons that can be induced to join the military, rather than by the military's demand. This assumption also implies that other qualified but less preferred groups are currently in excess supply and the Services can administratively control the number they desire to have enlist. These "demand constrained" groups include female high-school graduates; prior service personnel; male, mental-group IV, high-school graduates; and, to some extent, male, mental-group IIIB, high-school graduates. This latter group appears to be administratively controlled by the Air Force and the Navy and, to a lesser extent, by the Army and Marine Corps. A separate dependent variable was created for each Service as well as by race (white and non-white).

- Quality population. The first independent variable used in the model is the number of Qualified Military Availables (QMAs) that is contained in the relevant market recruited by the Services. The segment of the QMA market that was used in this analysis is the population of NPS, diploma high-school graduate, 17-21-year-old males, classified in mental categories I-IIIA, and not pursuing further schooling. Nationally, this subpopulation accounts for approximately 6 percent of the military available (MA) population. Both the enlistment and QMA counts were split by Service, mental group and race for male diploma graduates and are shown on Table 1.1.

- Recruiters on stations. The recruiter variable used in this analysis consists of estimates of production recruiters on station as of 31 October 1976. This was the only state level estimate of recruiter strengths available and it is presumed that the distribution of recruiters on this date is comparable to the average distribution during CY 1975. The fact that the recruiter variable entered in a large and statistically

Table 1.1

SUMMARY ENLISTMENT/QMA DATA

CY 1975

NPS Male Diploma Graduates

	Army	White	Non-white			TOTAL					
			1,2	3A	3B						
#	31,043	16,806	15,779	3,838	4	2,899	5,247	11,675	4,804	5	92,091
%	34	18	17	4		3	6	13		5	100
Navy											
#	30,334	17,797	11,176	2,921	4	1,742	2,376	2,744	1,031	2	70,121
%	43	25	16	4		3	3	4		2	100
USMC											
#	11,504	7,456	5,847	595	2	1,416	1,818	2,265	310	1	31,211
%	37	24	19	2		5	6	7		1	100
USAF											
#	24,528	15,303	9,863	463	1	1,704	2,681	2,728	95	57,365	
%	42	27	17	1		3	5	5		5	100
Total DOD											
#	97,409	57,362	42,665	7,817	3	7,761	12,122	19,412	6,240	2	250,788
%	39	23	17	3		3	5	8		2	100
QMA ^{b/}											
#	645,071	294,447	268,402	148,439	10	21,775	29,907	66,157	76,203	5	1,550,401
%	42	19	17	10		2	1	4		5	100

a/ Less than 0.5%.

b/ QMA includes QMA not in school, 15% of QMA in school because 15% of enlistees responded they were in school at time of enlistment on the May 1975 AFEEs survey, and DOD enlistments for CY 1975.

significant manner for each of these Service- and race-specific models tends to confirm that the assumption concerning recruiter distributions was correct.

- Unemployment. The variable used in these models represents general unemployment as a percent of the labor force and was extracted from the Employment and Training Report of the President (1976).

- Civilian pay. In order to account for regional variation and economic attractiveness of military service as an alternative to civilian pursuits, a civilian pay variable was included in the model. The data for this variable were extracted from Table C.13, "Salaries and Earnings of Production Workers on Manufacturing Payrolls by State and Selected Areas," in the BLS report, Employment and Earnings for August 1976. Payroll data used in the model are for June 1976.

Selection of the Model

A cross-sectional model was selected, involving a single annual observation on each of the 50 states in the U.S. This form of a model, rather than a time series model, was selected to obtain a sufficient range of values for each of the variables (especially population) to permit accurate estimation of the statistical relationships among the variables. Without the cross-sectional dimension to the model, there would not have been enough variation in the population variable over time during the relatively short period since the beginning of the AVF. Once a cross-sectional model was selected, only one year's data could be used because, at the time of the analysis, data on recruiter allocation across geographical area were available for only a one-year period.

A multiplicative Cobb-Douglas form of model was selected because it would be least sensitive to possible inaccuracies in the source data.

Estimation of Model Parameters

Conventionally, parameters of a multiplicative Cobb-Douglas model are computed by converting the model into its companion log linear form and solving for the approximate elasticities using a standard linear regression package. This procedure was not employed in the present analysis because it was found to produce significantly erroneous results. Rather, an improved

technique, called the Gauss-Marquardt least squares algorithm, was employed to obtain estimates not subject to the weaknesses of the conventional approximation procedure.

SUPPLY EFFECTS OF THE MODEL PARAMETERS

The elasticity of an explanatory variable is the percentage change in the dependent variable (in this case, NPS male HSG I-IIIA enlistments) with respect to a given percentage change in that explanatory, or independent, variable (population, unemployment, etc.). Elasticities of all variables in the model are summarized in Table 1.2. The data show, for example, that the population elasticity for Army white enlistments is .65. This means that a 10 percent change in this population category will result in a 6.5 percent change in white quality enlistments for the Army. While separate elasticities were computed for each Service by race for each of the variables, composite elasticities were also computed; these are shown on Table 1.3 on page 7.

Based on the individual and composite elasticities, the following observations appear relevant to this study.

- Population effect. The computed population elasticity for each Service is positive and significant; but, in each instance, the value is less than 1.0, meaning that a less-than-proportional decline in quality enlistments is expected to occur for a given percentage decline in the relevant youth population. The largest absolute and relative declines due to population are anticipated to occur in the Army while the smallest but still significant effect of the population decline impacts on the Air Force. Smaller population elasticities suggest a condition of excess supply of enlistable volunteers to a Service. This implies that the Air Force has the largest surplus and the Army the lowest (if any) and is thus the most sensitive to changes in population.

- Race-specific population effects. With the exception of the Air Force, population effects examined by race show that white enlistments are more sensitive to change in the white population than non-white enlistments are to changes in the non-white population. Since the real decline over the next decade in youth population is expected to occur in the white population, the differences in these elasticities tend to exacerbate the imbalance in the racial mix of enlistments when examined by Service.

Table 1.2
FINALIZED SUPPLY MODELS FOR I-III A, DHSG ACCESSIONS

Parameter	White		Non-white	
	Value	Standard error	Value	Standard error
c	4.50		22.41	
ϵ_q	.65	.10	.41	.15
ϵ_r	.34	.09	.54	.20
Army ϵ_u	.34	.11	-.42	.41
ϵ_e	1.16	.24	4.11	.56
R ²	.9624		.7505	
c	3.54		7.02	
ϵ_q	.44	.07	.35	.08
ϵ_r	.56	.06	.63	.08
Navy ϵ_u	-0-		-.53	.19
ϵ_e	.61	.23	1.18	.32
R ²	.9678		.9310	
c	1.85		5.99	
ϵ_q	.20	.09	.64	.08
ϵ_r	.73	.09	.21	.08
USAF ϵ_u	.25	.12	-0-	
ϵ_e	-0-		1.17	.37
R ²	.9495		.8755	
c	-.76		5.31	
ϵ_q	.57	.09	.55	.10
USMC ϵ_r	.37	.08	.26	.10
ϵ_u	-0-		-0-	
ϵ_e	-0-		1.04	.45
R ²	.9579		.8243	

Table 1.3

NON-RACE-SPECIFIC SUPPLY MODELS FOR I-IIIA DHSG ENLISTMENTS
(Values shown in the table represent elasticities)

Parameter	Army	Navy	Marine Corps	Air Force	DOD		
					White	Non-white	Total
Constant	7.11	3.81	.12	2.26	2.88	12.82	4.01
ϵ_q (population)	.62	.43	.57	.24	.46	.47	.46
ϵ_r (recruiters)	.37	.57	.35	.68	.51	.44	.50
ϵ_u (unemployment)	.23	-.04	-0-	.23	.17	-.28	.12
ϵ_e (pay)	1.59	.65	.15	.12	.55	2.36	.76

- Recruiter effect. The recruiter variable shows a positive and significant effect on quality enlistments for each Service. Relative magnitude of the recruiter effect when examined by Service shows a pattern opposite that of the population effects; that is, Air Force quality enlistments which are the least sensitive to population changes of the four Services are most sensitive to changes in the recruiter force. These differences are best exemplified by the marginal productivities of the respective Service recruiters which are computed from these elasticities.

Table 1.4

MARGINAL PRODUCTIVITIES OF SERVICE RECRUITERS
FOR NPS MALE, DHSG, I-IIIA ENLISTMENTS
(at CY 1975 supply levels)

<u>Army</u>	<u>Navy</u>	<u>Marine Corps</u>	<u>Air Force</u>
4.3	8.5	4.3	16.5

The results show that the Army and the Marine Corps have equivalent capability at the margin while the Navy and Air Force recruiters are two and four times as productive, respectively. These results are consistent with other evidence that enlistment preferences of youth differ markedly by Service. While youth generally express a preference for more than one

Service, the Air Force has a broader appeal to youth than the three remaining Services. This enlistment affinity for the Air Force is reflected in their production statistics.

- Unemployment effects. Interpretation of the results of the unemployment variables included in the model is not as clear and consistent as are the other parameters. Over all, the most significant unemployment effect is observed in the Army supply models. With regard to white Army enlistments, increasing unemployment has a positive effect, while for non-white Army enlistments it has a negative effect. The positive unemployment elasticity is what one would normally expect since depressed economic conditions make the military a more attractive option to a greater segment of the youth population. The anomalous effect of a rise in non-white enlistments as unemployment declines could be due to a number of reasons. One possible explanation is that non-whites traditionally are the last to be employed. Hiring practices by private employers under conditions of labor surplus typically result in a preference for white over non-white new hires. Thus, employment patterns in the civilian sector during certain phases of a business cycle can affect the racial composition of enlistees if the Services are recruiting in a nondiscriminatory mode. With respect to Navy enlistments, no unemployment effect for white enlistments was observed while a similar negative unemployment effect on non-white enlistments was observed. With respect to the Air Force, the opposite pattern occurred, that is, white enlistments appear to be affected by unemployment while non-white enlistments were unaffected. This latter observation may be attributed to the small size of the Air Force non-white enlistment population. No unemployment effects were observed on Marine Corps enlistments, either white or non-white.

- Compensation effects. The compensation variable is significant and relatively large for both Army and Navy enlistments. Further, when examined by race, the pay effect on Army non-white enlistments is approximately three and one-half times larger than for Army white enlistments. This observed difference is consistent with data that show significant differences in earnings potential for whites and non-whites. Thus, a comparable non-discriminatory salary offered by the military should be relatively more

attractive to the non-white population. A similar although not as extreme effect is observed with respect to pay on Navy enlistments. Regarding the Air Force and the Marine Corps white enlistments, the pay variable had no effect. A noticeable effect of a magnitude similar to that of the Navy was observed for non-white enlistments. Again, civilian sector pay differences between whites and non-whites seem to be operative here.

ENLISTMENT FORECAST RESULTS

In order to generate enlistment forecasts over the next decade, it was necessary to develop forecasts of the four independent variables included in the model. Since in large part the objective of the study was to measure the impact that a change in population and unemployment would have on enlistments, the other two variables — number of recruiters and relative military/civilian compensation — were presumed to be held constant throughout the forecast period. Should this assumption be altered, different enlistment forecasts would necessarily occur. The assumption particularly with respect to compensation is not without its budget implications since a major share of the increase in manpower costs over the past several years has been driven by the need to maintain comparability with the civilian sector, and undoubtedly it will remain an expensive feature of the defense budget.

Some valid criticism attaches itself to the use of cross-sectional results in time series models. This technique is not without precedent, however. Economists, badgered by problems analogous to those afflicting this study, have traditionally resorted to just such an approach in demand studies. The technique is now standard; but after over 20 years of debate, basic questions of appropriateness have not been resolved.

Population Forecast Variable

The forecast of population trends employed in the enlistment supply models are data developed by the U.S. Census Population Series II. The trend in the 17-21-year-old male population is depicted graphically on Fig. 1.1 on the following page.

As a general overview, these census population trends for 17-21-year-old males show that:

- Total population for this group increases by 3 percent from 10.5 to 10.8 million over the period 1975-1978; however, in the period 1978-1990 the same group decreases by 17 percent, from 10.8 to 9.0 million.
- The white population increases by 2.4 percent, from 9.0 to 9.2 million over the period 1975-1978, and decreases 20 percent from 9.2 to 7.4 million over the period 1978-1990.

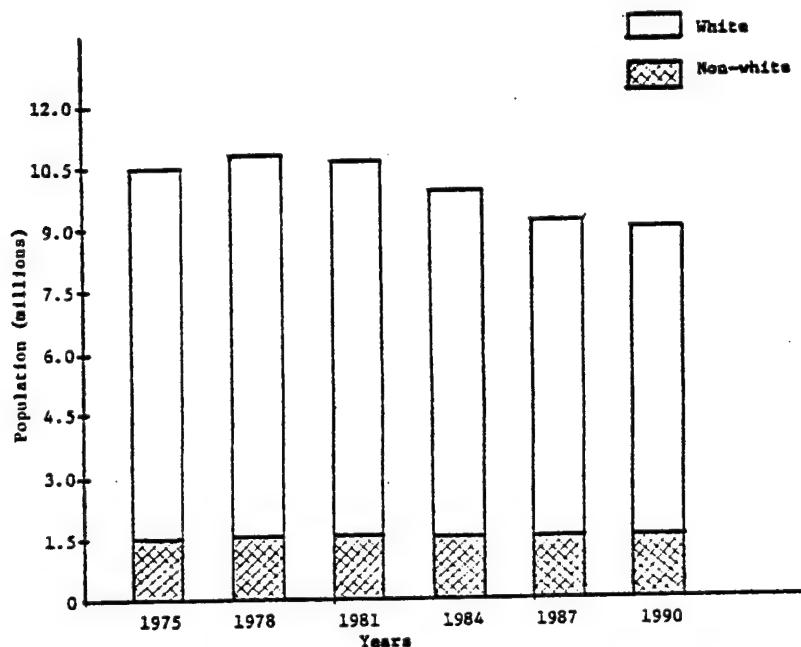


Fig. 1.1— POPULATION OF 17-21 YEAR OLD MALES
US CENSUS SERIES II
(In millions)

- In contrast to the white population, the non-white population increases 11 percent, from 1.5 to 1.7 million over the period 1975-1982, and levels off at 1.6 million by 1985.

Unemployment Forecast Variable

The forecasts of unemployment that are used as input for the supply model are those developed by the Congressional Budget Office and are the same ones used by CBO in forecasting enlistment supply in a recent budget issue paper.^{1/} Table 1.5 displays the historical trend in general in male youth unemployment rates as well as the CBO projections.

^{1/} The Costs of Defense Manpower: Issues for 1977, Congressional Budget Office, Congress of the United States, Washington, D.C., January 1977, especially Appendix A.

Essentially, CBO is forecasting the general unemployment rate will decline by some 45 percent over the decade 1975-1985.

Table 1.5

GENERAL AND 18-19 YEAR MALE UNEMPLOYMENT
RATES: HISTORICAL TREND AND CBO PROJECTIONS

Year	Actual rates		CBO Projections (Jan '77 projection)		
	Total rate	18-19 year males	Year	Total rate	18-19 year males
1972	5.6%	14.0%	1978	7.3%	17.2%
1973	4.9%	11.4%	1979	7.0%	16.5%
1974	5.6%	13.3%	1980	6.3%	15.3%
1975	8.5%	19.0%	1981	5.7%	13.9%
1976	7.7%	17.6%	1982	5.1%	12.7%
Mar '77	7.3%	17.2%	1983-85	4.6%	11.4%
Jun '77	7.1%	N/A			

Quality Enlistment Forecasts

Using the Census Population Projections and the unemployment forecasts developed by CBO, the Service-and race-specific supply models developed in this study produced quality enlistment forecasts as shown on Table 1.6.

The data show that if none of the relevant variables change except population and unemployment, the Services are likely to recruit 22,000 fewer quality enlistments by 1986 than obtained in 1975. While the aggregate decline is approximately 16 percent for DOD, the Army experiences the largest decline, with the Air Force ranked second, followed by the Marine Corps and Navy. The population and unemployment effects on the Marine Corps and Navy quality enlistments are much less significant, primarily because of minimal or nonexistent unemployment effects.

Changes in the Racial Mix of Quality Enlistments

Included in Table 1.6 are estimates of the racial mix of the quality enlistment group. The Army, for example, has a sizable decline in quality enlistments coupled with a rise in the proportion of these enlistments that

Table 1.6

SUMMARY OF I-III-A DHSG ENLISTMENT
 PROJECTIONS USING THE JANUARY '77
 CBO UNEMPLOYMENT PROJECTIONS

	Army		Navy		Marine Corps		Air Force	
	Total	% Non-white	Total	% Non-white	Total	% Non-white	Total	% Non-white
1975 (actual)	55,995	14	52,249	8	22,194	14	44,216	10
1978	55,308	16	53,143	8	22,579	15	43,311	11
1982	50,893	19	52,843	10	22,226	15	41,007	11
1986	44,354	22	49,198	12	20,546	16	38,617	12
% 1975-86	-21%	--	-6%	--	-7%	--	-13%	--

are non-white. The significant increase in the proportion of quality non-white enlistments entering the Army by 1986 can be accounted for by the inverse unemployment effect described earlier, that is, a decline in unemployment tends to reduce white quality enlistments but increase non-white quality enlistments. Changes in non-white enlistment proportions in the other Services are not as dramatic, primarily because of the minimal or nonexistent impact unemployment has on quality enlistments to these Services.

ACCESSION BUDGET IMPLICATIONS OF THE ENLISTMENT SUPPLY FORECASTS

There have been a number of studies ongoing within DOD and elsewhere which are examining the feasibility and cost of satisfying its manpower requirements with alternative sources of supply. This includes greater use of women, civilians, contract hires, and prior service personnel. As a complement to these studies, it was decided to estimate what the cost is likely to be of continuing the present policy of recruiting male high-school graduates in numbers sufficient to maintain the current quality mix. Again, it was assumed that relative civilian/military compensation remains constant over the next decade and that the additional costs that accrue to the accession budgets are due solely to declines in both unemployment and population.

Optimal Accession Budget Allocations

In order to estimate the budgetary implications of the enlistment shortfalls, an optimal budget allocation model has been employed. This model was developed under previous contract work for Department of the Army and Office Secretary of Defense.^{2/} Two fundamental assumptions were implicit in the modeling methodology. First is that the programs diminish in effectiveness at an exponential rate and at some point provide no additional enlistments for each increment in the budget. The second assumption is that various accession programs such as recruiters, advertising, and recruiter aids are to some extent substitutes for one another.

Accession Budget Production Functions at CY 1975 Enlistment Supply Levels

Based on output from the optimal budget allocation model, Fig. 1.2 displays the series of accession budget production functions for CY 1975 enlistment supply levels.

^{2/} Documentation Report to Support the Analysis for Management of Recruiting Resources and Operations (AMRRO) System, General Research Corporation, CR-189, June 1977.

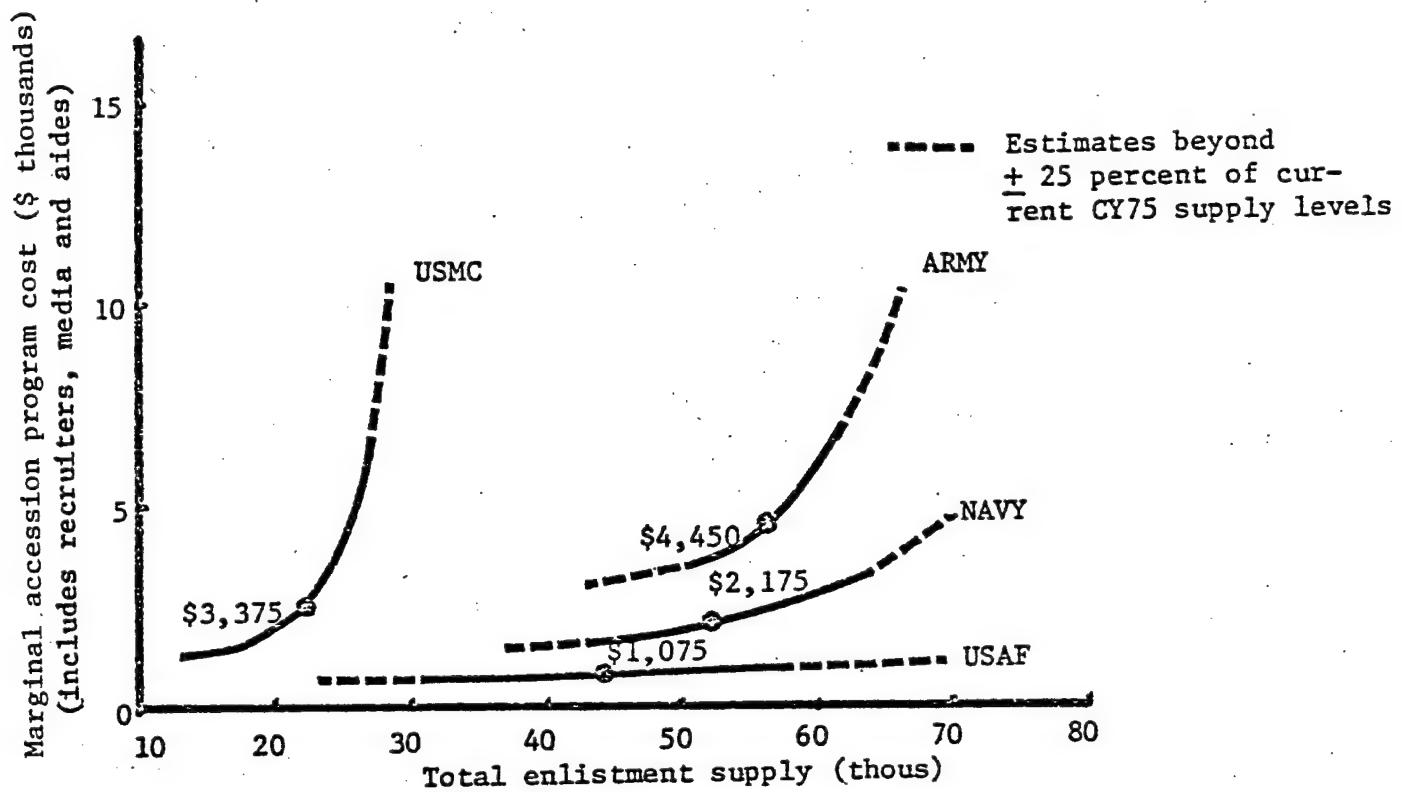


Fig. 1.2—Accession Production Functions
NPS Male, DHSG, I-IIIA (at CY 75
supply levels)

The numbers annotated on each curve represent the marginal accession costs of recruiting the next additional quality enlistment at CY 1975 supply levels. What is most apparent in the curves is the difference in production capability between the Marine Corps and Air Force. It would appear that the Air Force can recruit essentially an unlimited supply of volunteers with only minimal increases in its marginal cost. The slope of the Air Force production function is consistent with the broad appeal the Air Force enjoys among the enlistable market. The Marine Corps is at the other extreme — it appeals to only a select segment of the market. The Marine Corps' recruiting strategy, which appears successful at current accession rates, presents a higher risk strategy when compared to the other

Services. Any increase in quality enlistment requirements for the Marine Corps will tend to drive up marginal recruiting costs much more sharply than the other Services.

Shifts in the Accession Budget Production Functions

Reduction in supply due to declines in unemployment and population tend to shift these Service accession production functions upward and to the left. This effect is depicted in Figure 1.3.

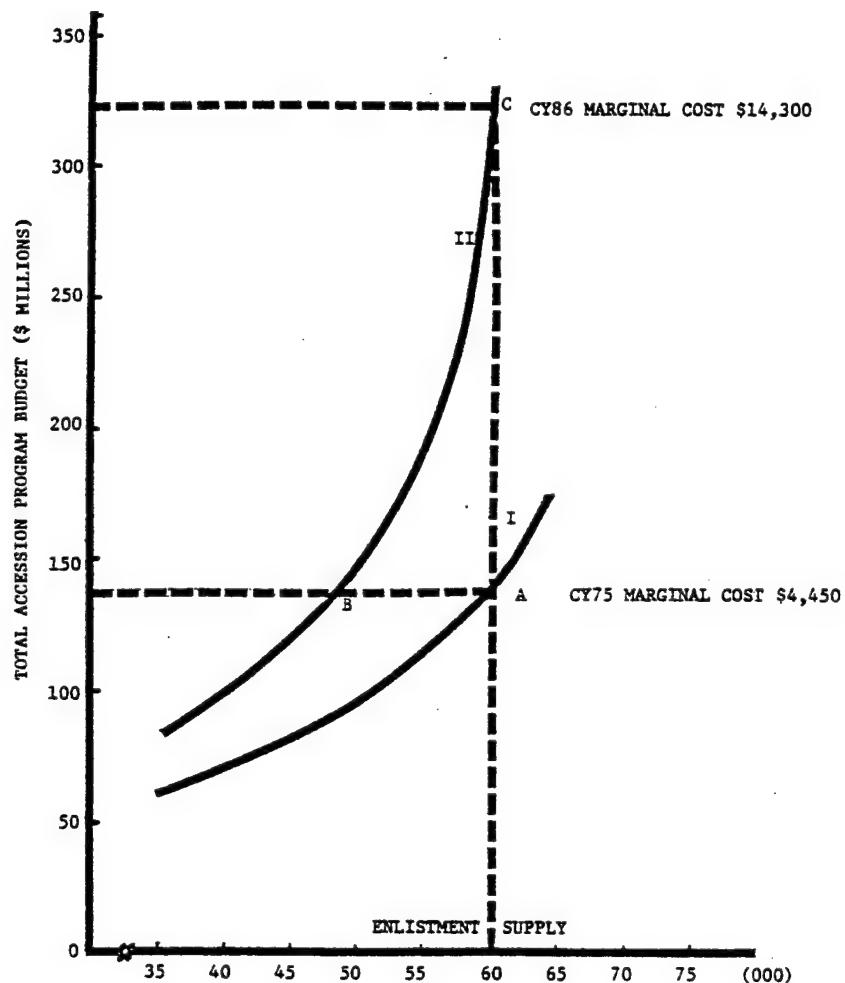


Fig. 1.3—Army Accession Production Functions
NPS Male, DHSG, I-III A

This figure shows schematically the magnitude of shift in the Army production function that should occur when the supply of the enlistable market is reduced by declines in unemployment and population through projected CY 1986 levels. The curve labelled I is essentially an expanded version of the Army production function curve shown on Fig. 1.2. This is the production function the Army operated on when CY 1975 population and unemployment conditions were in effect. Point A represents the recruiting environment under CY 1975 resource levels. The slope of the curve at Point A (\$4,450 per accession) is the marginal cost of recruiting the next additional quality enlistment in the CY 1975 recruiting environment.

The curve labelled II is the anticipated production function the Army will face at CY 1986 enlistment supply levels. Assuming no change in the accession budget beyond that established in CY 1975, Point B shows that the Army can anticipate recruiting 21 percent fewer enlistments should it decide (or be forced) to maintain a status quo in its accession budget. Should the Army wish to restore the total number of enlistments lost due to the population and unemployment decline, it will have to increase its accession budget along production function II up to Point C. At that point, it will have achieved the same number of enlistments it realized in CY 1975 but the marginal cost of the next additional enlistment is approximately three times larger than it was in CY 1975 conditions.

The curves shown in Fig. 1.3 indicate that without changes in the attractiveness of Army Service, a \$90 million per year, i.e., a 56 percent, increase in the accession budget will be required by CY 1986.

Accession Budgets Required to Eliminate Quality Enlistment Shortfalls

The size of the accession budget for each Service required to overcome projected declines and their enlistments is shown on Table 1.7. As stated earlier for the Army, the table shows that a 21 percent shortfall in quality enlistments is projected by 1986 and a constant dollar increase in the accession budget of 56 percent will be required to increase the Army's market penetration sufficiently to offset this shortfall in enlistments.

The Navy's situation is much less severe than the Army and a shortage of enlistments is not projected until after 1982. This shortfall is

Table 1.7
 CHANGE IN ACCESSION BUDGET TO OVERCOME
 PROJECTED DECLINE IN NPS MALE DHSG I-IIIA
 FROM CY 1975 LEVEL

Shortfall from CY'75 level	Accession budget required to maintain CY'75 levels (millions CY'75 \$)	Average cost per enlistment (CY'75 \$)	Marginal cost per enlistment (CY'75 \$)
			(CY'75 \$)
<u>ARMY</u>			
CY 1975 actual	55,995	\$ 160.	\$ 2,860
CY 1978	(2,500)	175.	3,125
CY 1982	(6,500)	190.	3,400
CY 1986	(11,641)	250.	4,460
<u>NAVY</u>			
CY 1975 actual	52,249	111.0	2,125
CY 1978	+ 894	107.5	2,060
CY 1982	+ 594	108.0	2,070
CY 1986	(3,051)	115.0	2,200
<u>MARINE CORPS</u>			
CY 1975 actual	22,194	48.0	2,160
CY 1978	+ 385	46.5	2,100
CY 1982	+ 32	48.0	2,160
CY 1986	(1,648)	53.0	2,390
<u>AIR FORCE</u>			
CY 1975 actual	44,216	54.0	1,220
CY 1978	(905)	55.0	1,240
CY 1982	(3,209)	56.5	1,280
CY 1986	(5,599)	58.0	1,310

expected to be less than 6 percent and a constant dollar increase to the accession budget of less than 4 percent would be sufficient to compensate for the Navy's shortage. In relative terms, the Marine Corps' projected shortfall is slightly larger than the Navy. A 10 percent increase in the accession budget will be required by 1986 to offset their projected shortage in quality enlistments. The relative shortfall projected for the Air Force is second only to the Army. A steady decline in quality enlistments is projected over the decade. This is projected to be 13 percent below the CY 1975 base levels. In spite of this relatively large decline for the Air Force, only a modest increase of 7 percent in the accession budget would be required to eliminate the shortfall. This relatively small increase in the Air Force accession budget reflects their highly productive recruiter force which at the margin is four times more productive than Army recruiters for the same quality group.

NEED FOR ADDITIONAL RESEARCH

This analysis has been a pioneering effort because no previous studies have been conducted that treat QMA population as an explanatory variable in the supply equation for volunteer enlistments. Previous studies have assumed that the supply of accessions varies proportionately with population and that this proportional relationship holds for all Services. The GRC analysis indicates that this popular assumption is not correct, that accession supply varies less-than-proportionately with population, and that this relationship differs among the Services.

Table 1.8 shows the implications of the GRC findings by comparing two projections of accession supply: one based on the GRC model, the other based on the assumption that supply varies proportionately with population. (Under both assumptions, the projections reflect the effect of projected changes in unemployment rates on the level of quality accessions. These effects differ among Services.) Table 1.8 shows that the projected decline in accessions between 1978 and 1986 will be only about half as great for the Navy, Marine Corps, and Air Force as would have been expected under the assumption of a proportional effect. The projected declines are most similar for the Army because the GRC analysis finds the population effect for the Army to be the closest to a proportional effect of all the Services.

Table 1.8
 PROJECTED DECLINES IN QUALITY ACCESSION LEVELS
 UNDER ALTERNATIVE ASSUMPTIONS CONCERNING
 POPULATION EFFECTS ^{a/}
 (Percent change 1978 to 1986)

	<u>GRC model</u>	<u>Proportionality_{b/} assumed</u>
Army	- 20%	- 24%
Navy	- 7	- 14
Marine Corps	- 9	- 15
Air Force	- 11	- 24

^{a/} Assumes CBO unemployment projection of January 1977.

^{b/} Assumes effects of variables other than population are as estimated in the GRC model.

No claim is made here that this analysis conclusively establishes the effects of population. Ideally, a time-series model would have been developed to analyze the effect of population changes because policy makers interested in this effect naturally want to apply the results of any population analysis to future situations — by definition, a time-series application. GRC purposely selected a cross-sectional, rather than a time-series, model because time-series data provided too little variation in population over the AVF period to support valid statistical estimates. Although this decision was appropriate, it was not without its problems.

Some rather stringent assumptions have to be true before a cross-sectional model can be applied to time-series projections. These assumptions are least likely to be true if the model is incompletely specified — that is, if one or more variables are omitted from the model that are correlated with variables that are included in the model. This could result in attributing the effects of the omitted variables to the included variables, which would distort any projections based on the model's parameters. For this reason, additional research is required to determine

whether different or additional variables should be included in the model and to test whether the model's results are stable when the model is applied to additional data. Possible modifications to the model include the use of youth unemployment rates and race-specific unemployment data rather than general unemployment rates. In addition, earnings statistics more closely tied to the youth labor market could be substituted for the manufacturing earnings data used in the present analysis.

This additional research was not possible in the present study because of study resource limitations. GRC believes strongly that this study ought not to be ignored but, rather, that it be supported with additional analysis.

Also because of resource limitations, the present analysis does not address the implications of the study findings for the optimal allocation of recruiters across geographical areas. In general, the Services tend to allocate their recruiters in proportion to population; the findings of the GRC model indicate that the best relationship between recruiter level and population is not a simple proportional one and that, in addition, the best relationship depends on unemployment rates and relative civilian wages across geographical areas. With modest additional analysis, it would be possible to calculate how much quality accession levels could be increased by reallocating recruiters.

Chapter 2

BACKGROUND AND PURPOSE

OBJECTIVES OF THE STUDY

This report was prepared for the Office Assistant Secretary of Defense, Manpower, Reserve Affairs and Logistics. The study was prompted by concern that the AVF faces serious manpower supply problems over the next decade. Specifically, four issues were addressed in the study:

- What effect, if any, will a projected decline in the youth population (17-21-year-old) have on quality enlistments over the next decade?
- What will be the effect on the supply of quality enlistments if the economy continues to improve and the unemployment rate continues to decline?
- If a decline in quality enlistments is projected over the next decade, what additional recruiting resources would be required to offset this decline?
- What are the manpower policy implications of attempting to sustain the AVF in the face of potential shortages of quality volunteers?

BACKGROUND INFORMATION SUPPORTING THE RATIONALE FOR THE STUDY

High-School Graduates: The Quality Recruiting Market

In examining public testimony, it is quite clear that DOD has measured the success of its AVF accession program by the number of male high-school graduates they are able to recruit. There are essentially two reasons for this. The first is that high-school graduates in contrast to non-graduates represent a better employment risk and the services typically experience considerably less attrition with a high-school graduate, as is evident from the following table.

Table 2.1

TRENDS IN MALE ENLISTED ATTRITION RATES DURING THE FIRST
 TWO YEARS OF SERVICE
 (All services combined)

Cohort	Percent attrition by year of accession			
	FY 1971	FY 1972	FY 1973	FY 1974
Total males	20.7	21.3	23.6	29.1
Male HSG	14.3	15.5	17.1	17.9
Male non-HSG ^{a/}	32.2	32.4	35.2	41.7

^{a/} Includes GEDs

Source: Defense Manpower Data Center

While the overall trend shows that attrition has been rising, male high-school graduates experience an attrition rate of less than one-half that of their non-graduate counterparts. Given the failure rate of non-graduates and the attendant costs associated with them, it is understandable why the services concentrate their energy and resources on recruiting high-school graduates.

The second reason for recruiting high-school graduates is basically that they are an identifiable market with uncertain career aspirations that can be both contacted and influenced by military recruiters. In certain respects, high-school seniors can be considered a homogeneous market who are segmented by the educational system. Once high-school seniors graduate, they become less easily identified and have, for the most part, already made career commitments that would exclude them as good prospects by military recruiters.

One should not conclude from this, however, that the male high-school senior segment of the youth population is the only market recruiters actively pursue, but it is unquestionably their prime target at present. In view of the fact that this market will tighten considerably, the services will have to both sharpen their recruiting techniques as well as broaden the enlistable

market by more active recruiting of alternative sources of supply, particularly females and possibly college students. At the present time, slightly more than half of the graduating class of male high-school seniors continue their education in institutions of higher learning. It is worth noting, however, that approximately 40 percent of this group leave these institutions by the end of 3 years. Surprisingly, quite a few of these individuals enlist in the military as evidenced by the fact that approximately 15 percent of NPS enlistments, responding to a May 1975 AFEES survey, claimed some post-high-school educational experience prior to enlisting.

Trends in High-School Graduate Enlistments

For the 12-month period ending June 1977, the services enlisted a combined total of approximately 260,000 diploma high-school graduates or 67 percent of their NPS male and female accessions. This is roughly 5 percent fewer than the number recruited in the previous 12-month period, and the majority of this decline occurred in the Army. The trend in the proportion of NPS enlistments who are high-school graduates appears in the following table.

Table 2.2

TRENDS IN DIPLOMA HIGH-SCHOOL GRADUATE ACCESSIONS EXPRESSED AS A PERCENT OF NPS ENLISTMENTS

Fiscal year	Army	Navy	Marine Corps	Air Force	DoD
FY 1964 ^{a/}	67	58	61	84	68
FY 1971	62	75	48	85	69
FY 1973	60	71	51	87	67
FY 1974	50	52	50	92	61
FY 1975	58	71	53	91	65
FY 1976	59	76	62	89	69
Jul76-Jun77	54	73	67	87	67
FY 1977 ^{b/}	52	71	65	87	65

^{a/} Some GEDs included.

^{b/} Through June.

Statistics presented in this form result in no clear pattern of the quality mix in military enlistments. There are probably as many administrative controls as there are market forces that are affecting high-school graduate accession rates for each service. The Army at present is several percentage points behind its objective of 68 percent diploma graduates and it appears very unlikely that such a target is attainable at present accession requirement levels. Overall, the Marine Corps shows the best improvement in its high-school graduate mix, but is still below its target of 70 percent diploma graduates of NPS enlistments. While it is difficult to say categorically that DOD is experiencing a downward trend in its high-school graduate enlistment level, it is clear that at best they have reached a plateau. The major reason for hesitancy in claiming a clear downward trend in high-school enlistments is the fact that the stock of high-school graduates in the Delayed Enlistment Pool is approximately 60 percent higher than the like period last year. This growth in the DEP can be partially ascribed to the cancellation of the GI Bill program at the end of 1976 and the corresponding surge in DEP enlistment contracts signed prior to the end of that year.

Trends in Unemployment

One of those market forces that appears to affect the level of quality enlistments is the civilian unemployment rate. Trends and projections of these unemployment rates are shown in the following table.

Table 2.3
GENERAL AND 18-19 YEAR MALE UNEMPLOYMENT RATES:
HISTORICAL TREND AND CBO PROJECTIONS

Year	Actual rates		CBO Projections (Jan '77 projection)		
	Total rate	18-19 year males	Year	Total rate	18-19 year males
1972	5.6%	14.0%	1978	7.3%	17.2%
1973	4.9%	11.4%	1979	7.0%	16.5%
1974	5.6%	13.3%	1980	6.3%	15.3%
1975	8.5%	19.0%	1981	5.7%	13.9%
1976	7.7%	17.6%	1982	5.1%	12.7%
Mar '77	7.3%	17.2%	1983-85	4.6%	11.4%
Jun '77	7.1%	N/A			

CY 1975 represents a peak year of unemployment and the trough of the most recent economic recession. This is also the year analyzed by GRC to estimate the effect that unemployment, compensation, population and recruiters have on quality enlistments across the 50 states and the District of Columbia.

The unemployment projections shown on Table 2.3 are the same ones used by CBO in forecasting enlistment supply in a recent issue paper.^{1/} These same unemployment projections developed by CBO are used in this report to develop enlistment forecasts. Note that a comparison of the actual rates with the CBO projections shows that the current (June 1977) general unemployment rate is already below the average projected by CBO for 1978. If this trend continues, the effect that declining unemployment has on enlistments will be more immediate. This fact should be kept in mind in evaluating the validity of the estimates developed in this report.

Trends in Youth Population

Coupled with the projected decline in unemployment is a known decrease in youth population over the next decade and beyond. This decline in population is depicted on Fig. 2.1. Detailed data on the number and rate of decline are displayed on Tables 2.4 and 2.5.

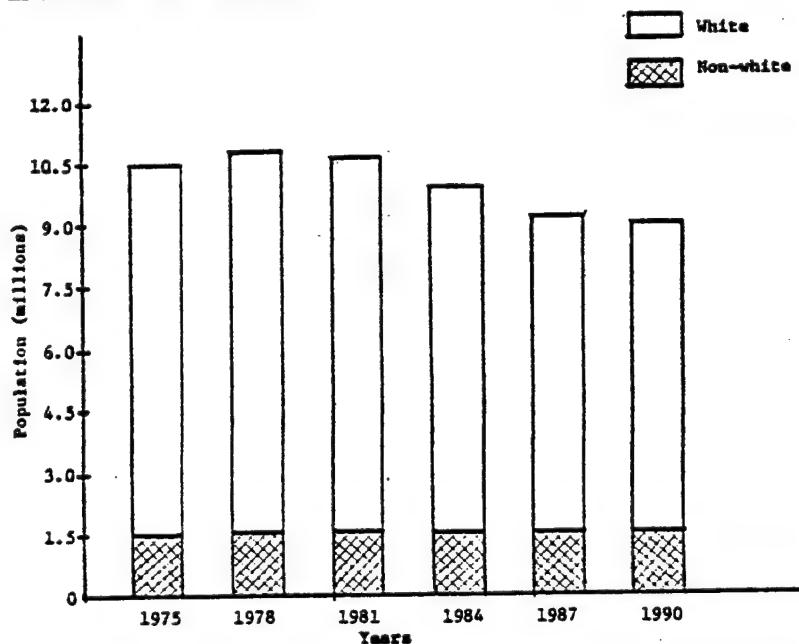


Fig. 2.1-- POPULATION OF 17-21 YEAR OLD MALES
US CENSUS SERIES II
(In millions)

^{1/} Budget Issue paper, "The Costs of Defense Manpower: Issues for 1977," especially App A, Congressional Budget Office, Congress of the United States, Washington, D.C., January 1977.

Table 2.4

PERCENT CHANGE IN MALE POPULATION, 17-21 YEARS OLD, BY RACE (SERIES II)

As of 1 July	Total		White		Non-white		Black		Other	
	Percent change Year to year	Cumulative from 1975								
1976	+ 1.3	+ 1.3	+ 1.0	+ 1.0	+ 3.0	+ 3.0	+ 2.6	+ 2.6	+ 5.9	+ 5.9
1977	+ 0.8	+ 2.1	+ 0.6	+ 1.6	+ 2.2	+ 5.2	+ 1.8	+ 4.4	+ 5.0	+10.9
1978	+ 0.9	+ 3.1	+ 0.8	+ 2.4	+ 1.9	+ 7.1	+ 1.7	+ 6.1	+ 3.7	+14.6
1979	- 0.2	+ 2.9	- 0.4	+ 2.0	+ 1.1	+ 8.2	+ 0.9	+ 7.0	+ 2.6	+17.2
1980	- 0.5	+ 2.5	- 0.7	+ 1.3	+ 1.1	+ 9.3	+ 0.7	+ 7.7	+ 4.0	+21.2
1981	- 0.7	+ 1.8	- 0.9	+ 0.4	+ 0.7	+10.0	+ 0.3	+ 8.0	+ 2.9	+24.1
1982	- 1.5	+ 0.3	- 1.8	- 1.4	+ 0.3	+10.3	- 0.1	+ 7.9	+ 2.8	+26.9
1983	- 2.8	- 2.5	- 8.1	- 9.5	- 0.6	+ 9.7	- 1.3	+ 6.6	+ 4.1	+31.0
1984	- 3.0	- 5.5	- 3.3	-12.8	- 1.6	+ 8.1	- 1.9	+ 4.7	+ 0.4	+31.4
1985	- 3.2	- 8.5	- 3.5	-16.3	- 1.7	+ 6.4	- 2.2	+ 2.5	+ 1.7	+33.1
1986	- 2.8	-11.0	- 3.1	-19.4	- 1.2	+ 5.2	- 1.8	+ 0.7	+ 2.1	+35.2
1987	- 1.4	-12.2	- 1.6	-21.0	- 0.4	+ 4.8	- 1.0	- 0.3	+ 3.3	+38.5
1988	+ 0.2	-12.1	- 0.0 ^a	-21.0	+ 1.3	+ 6.1	+ 0.9	+ 0.6	+ 3.6	+42.1
1989	- 0.8	-12.8	- 1.1	-22.1	+ 0.9	+ 7.0	+ 0.4	+ 1.0	+ 3.5	+45.6
1990	- 1.5	-14.1	- 1.9	-24.0	+ 0.2	+ 7.2	- 0.3	+ 0.7	+ 2.6	+48.2
1991	- 2.2	-16.0	- 2.5	-26.5	- 0.6	+ 6.6	- 1.0	- 0.3	+ 1.5	+49.7
1992	- 2.3	-17.9	- 2.9	-29.4	- 0.3	+ 6.3	- 0.6	- 0.9	+ 4.7	+54.4
1993	- 2.2	-19.7	- 2.6	-32.0	- 0.4	+ 5.9	- 1.2	- 2.1	+ 3.4	+57.8
1994	+ 0.3	-19.4	+ 0.1	-31.9	+ 1.4	+ 7.3	+ 0.5	- 1.6	+ 5.7	+63.5
1995	+ 2.5	-17.4	+ 2.4	-29.5	+ 2.8	+10.1	+ 2.1	+ 0.5	+ 5.7	+69.2
1996	+ 3.6	-14.4	+ 3.7	-25.8	+ 3.6	+13.7	+ 2.5	+ 3.0	+ 8.1	+77.3
1997	+ 3.9	-11.1	+ 4.2	-21.6	+ 2.5	+16.2	+ 2.1	+ 5.1	+ 4.1	+81.4
1998	+ 3.8	- 7.8	+ 4.1	-17.5	+ 2.3	+18.5	+ 1.9	+ 7.0	+ 3.7	+85.1
1999	+ 3.3	- 4.7	+ 3.6	-13.9	+ 1.9	+20.4	+ 1.5	+ 8.5	+ 3.3	+88.4
2000	+ 2.7	- 2.2	+ 2.9	-11.0	+ 1.5	+21.9	+ 1.1	+ 9.6	+ 3.0	+91.4

^aLess than 0.05%

Table 2.5

MALE POPULATION, 17-21 YEARS OLD, BY RACE (SERIES II)^{a/}, 1975-2000
(thous)

Age of 1 July	Total	White	Non-white	Black	Other	Percent white of total		Percent non-white of total		Percent black of total		Percent Other of total
						Percent white of total	Percent non-white of total	Percent black of total	Percent Other of total	Percent white of total	Percent non-white of total	
1975	10481	8980	1501	1331	170	85.7	14.3	12.7	1.6	14.6	12.9	1.7
1976	10618	9072	1546	1366	180	85.4	14.6	12.9	1.7	14.8	13.0	1.8
1977	10707	9128	1580	1391	189	85.2	14.8	13.0	1.8	14.9	13.1	1.8
1978	10808	9199	1610	1414	196	85.1	14.9	13.1	1.8	15.1	13.2	1.9
1979	10791	9162	1628	1427	201	84.9	15.1	13.2	1.9	15.3	13.4	1.9
1980	10740	9094	1646	1437	209	84.7	15.3	13.4	1.9	15.5	13.5	2.0
1981	10669	9012	1657	1442	215	84.5	15.5	13.5	2.0	15.8	13.7	2.1
1982	10511	8850	1662	1441	221	84.2	15.8	13.7	2.1	16.2	13.9	2.3
1983	10215	8565	1652	1422	230	83.8	16.2	13.9	2.3	16.4	14.1	2.3
1984	9909	8282	1626	1395	231	83.6	16.4	14.1	2.3	16.7	14.2	2.5
1985	9593	7993	1599	1364	235	83.3	16.7	14.4	2.5	17.1	14.4	2.5
1986	9328	7749	1580	1340	240	83.1	16.9	14.4	2.5	17.4	14.7	2.7
1987	9199	7624	1574	1326	248	82.9	17.1	14.4	2.7	17.7	15.0	2.8
1988	9217	7621	1595	1338	257	82.7	17.3	14.5	2.8	18.0	15.3	3.0
1989	9145	7534	1609	1343	266	82.4	17.6	14.7	2.9	18.3	15.5	3.4
1990	9005	7392	1612	1339	273	82.1	17.9	14.9	3.0	18.6	15.7	3.5
1991	8808	7207	1602	1325	277	81.8	18.2	15.0	3.1	19.0	16.0	3.7
1992	8605	7000	1607	1317	290	81.3	18.7	15.3	3.4	19.3	16.4	3.9
1993	8417	6816	1601	1301	300	81.0	19.0	15.5	3.5	19.6	16.2	4.1
1994	8444	6821	1624	1307	317	80.8	19.2	15.5	3.7	19.9	16.0	4.0
1995	8656	6984	1670	1335	335	80.7	19.3	15.4	3.9	20.2	16.7	4.1
1996	8971	7240	1730	1368	362	80.7	19.3	15.2	4.0	20.5	16.5	4.0
1997	9317	7544	1774	1397	377	81.0	19.0	15.0	4.0	20.8	16.3	4.1
1998	9669	7855	1814	1423	391	81.2	18.8	15.7	4.1	21.1	16.5	4.0
1999	9985	8136	1848	1444	404	81.5	18.5	15.5	4.0	21.4	16.2	4.1
2000	10253	8376	1876	1460	416	81.7	18.3	14.2	4.1	21.7	16.0	4.1

^{a/}US Census, Current Population Reports, Series P-25, No. 601, issued October 1975.

As a general overview, the census population trends for 17-21-year old males show that:

- Total population for this group increases by 3 percent, from 10.5 to 10.8 million over the period 1975-78; however, from the period 1978-90, this same group decreases by 17 percent, from 10.8 to 9.0 million.
- The white population increases by 2.4 percent, from 9.0 to 9.2 million over the period 1975-78, and decreases 20 percent, from 9.2 to 7.4 million over the period 1978-90.
- In contrast to the white population, the non-white population increases 11 percent, from 1.5 to 1.7 million over the period 1975-82 and levels off at 1.6 million by 1985.

As is evident from these data, the real decline occurs in the white population and, because of this, there are changes in both the total population and racial composition that have important implications for sustaining a quality AVF that is also representative of the characteristics of the U.S. population. In developing enlistment forecasts for this report, the rates of change in both white and non-white populations under the census Series II projections were used.

While the actual enlistment forecasts for this report are based on census population trends, it is worth noting that the rate of decline by geographic area is not uniform. GRC is currently in the process of turning over to the Defense Manpower Data Center its Qualified Military Available (QMA) population projection system. An examination of the QMA projections by state reveals considerable variance in the rate of projected decline as shown in the sample of ten states in Table 2.6 on the following page.

These data show that the prime market of military recruiters is projected to decline by 14 percent for both the top ten states (ranked by population) and the nation as a whole. When the trends in the individual states are examined, however, significant differences are apparent such as New York, which is projected to experience only a 1 percent decline in this population group, while at the other extreme, Michigan's prime enlistment market is expected to shrink by 22 percent over the next decade. The primary reason for this variation in rates of decline is the difference in net migration that is experienced by each of the states. The population

Table 2.6
 DISTRIBUTION OF THE TOP TEN STATES
 QMA I-IIIA MALE HSG
 17-21 YEAR OLD

	CY 1975	CY 1985	% Δ 1975-85
CALIFORNIA	158,201	137,543	- 13%
NEW YORK	129,246	127,982	- 1%
PENNSYLVANIA	109,622	89,323	- 19%
ILLINOIS	110,462	95,194	- 14%
OHIO	107,692	89,090	- 18%
MICHIGAN	85,624	67,529	- 22%
TEXAS	63,751	53,301	- 17%
INDIANA	55,626	48,869	- 13%
WISCONSIN	55,395	47,328	- 15%
MINNESOTA	54,195	48,281	- 11%
TEN STATE TOTAL	929,814	804,440	- 14%
NATIONAL TOTAL	1,652,071	1,417,359	- 14%
TEN STATE % OF TOTAL	56.3%	56.8%	

projections displayed on Table 2.6 assume that the current pattern of net migration will remain unchanged through the 1980's. These differences in rates of decline by geographic region are important because they will affect the placement of recruiters, and it points to the need for DOD to track population movements on a regional basis. The migration data used in the QMA system are available from the states on an annual basis, and CY 1974-75 data were used in forecasting QMA. In turning the GRC-developed QMA system over to the Defense Manpower Data Center, DOD will have in-house capability to track migration trends on an annual basis.

Trends in School Enrollment

In monitoring the overall population dynamics in the marketplace, DOD needs to be aware of the patterns in high-school completion rates and post-high-school continuation rates. For example, high-school completion rates for both males and females have remained practically unchanged over the past decade, as shown in the following table.

Table 2.7

NUMBER OF HIGH SCHOOL GRADUATES
COMPARED WITH POPULATION 17-YEAR-OLDS

School year ending	Male		Female	
	Graduates (000)	Percent of 17-year-olds	Graduates (000)	Percent of 17-year-olds
1940	579	46%	643	52%
1950	571	54%	629	61%
1965	1,314	74%	1,351	79%
1975	1,541	72%	1,599	77%

Source: The Condition of Education, 1977 Edition, National Center for Education Statistics, p 174.

As the data show, approximately 75 percent of the 17-year-old population completed high school in 1975. While there continues to be some growth in completion rates, especially for black females, DOD cannot expect the population of the high-school graduate market to be measurably affected by any change in high-school completion rates over the next several years. Given that the high-school graduate completion rate is likely to remain constant, population trends will be the driving force behind the size of this high-school graduate market. As we have noted elsewhere in this chapter, the population of this prime age group is expected to decline substantially over the next decade.

The other factor to consider is college enrollment patterns. Since the decision to enter either 2- or 4-year institutions of higher learning effectively excludes that individual from the enlistable market for the active force, unlike high-school completion rates, the pattern in college enrollments is not clearly defined. This is exemplified by the data on Table 2.8 on the following page. For the 1976-77 academic year, the data show a slight decline in the total population of those enrolled in a 4-year college. Perhaps of more interest, however, is the pattern of freshman enrollment changes over the past several years. It is difficult

Table 2.8

ANNUAL PERCENTAGE CHANGE IN COLLEGE ENROLLMENTS, MALE AND FEMALE
(For 4-year and related institutions)

<u>Year</u>	<u>Full-time</u>	<u>Part-time</u>	<u>Grand total</u>	<u>Freshmen</u>
1970	+ 4.9	+ 2.2	+ 4.2	+ 3.8
1971	3.2	.9	2.6	- .7
1972	- .4	2.1	.2	- 3.1
1973	2.1	5.9	1.8	- 1.7
1974	2.0	8.0	3.7	4.6
1975	2.9	7.7	4.3	7.4
1976	.2	- 3.2	- .8	3.7

Source: Collegiate Enrollments in the U.S., 1976-77, American College Testing Program, 1977.

to detect any clear trend in the data and an extrapolation of these results to develop projections is fraught with uncertainty. For example, the growth rate for male college freshmen in the present academic year compared with last year is 2.6 percent contrasted with 4.9 percent for women. Thus, the impact that females (and minorities) have on the freshman enrollment population is a key factor in estimating the size of the male enlistable market. ^{2/}

Enrollment patterns in 2-year colleges are also difficult to interpret. One study estimates that freshman enrollment in 2-year colleges increased by 8.4 percent in the 1976-77 academic year when compared to the previous year. However, when examined by sex, the increase was only 2 percent for males vs 17 percent for females. ^{3/}

^{2/} Collegiate Enrollments in the U.S., 1976-77, American College Testing Program, 1977, p 12.

^{3/} College Enrollments in American 2-Year Institutions, 1976-77, American College Testing Program, 1977, p 14.

The effect that a declining youth population will have on college enrollments is very uncertain. The trend toward excess capacity in the education industry as the population declines may increase competition for the prime candidate of military recruiters—the high-school graduate. The extent of educational subsidies by Federal, state and local governments can be a contributing factor to this excess capacity and actually induce unnecessary and counterproductive competition for the reduced youth market. To some extent, the loss of the GI bill will aggravate the excess capacity condition and likely prompt educational administrators to more aggressively recruit non-veteran, high-school graduates to offset this loss.

While military recruiters actively pursue the recent high-school graduate, it is misleading to think that the vast majority of NPS DHSG enlistments are recent high-school graduates. The AFEES survey conducted in May of 1975 provides an estimate of the age distribution of those immediately entering active duty or enlisting in the DEP. This is shown on the following table.

Table 2.9
PERCENTAGE DISTRIBUTION BY AGE FOR MALE
AND FEMALE DHSG ENLISTEES ACCORDING TO
THE MAY, 1975 AFEES SURVEY

Age	17	18	19	20	21	>21	Total
NPS	7	21	24	16	11	20	100%
PS + NPS	6	19	22	15	10	28	100%

Somewhat surprisingly, the results show that one-fifth of NPS DHSG enlistments passed their 21st birthday. The data suggest that for a large number of high-school graduates there is a considerable lapse of time between completion of high school and actual enlistment in the military. While the AFEES survey data represent only a one-month's snapshot which is subject to seasonal bias, the results are probably reasonably indicative of the true age distribution of enlisting high-school graduates.

Additional information on the AFEES survey shows that about 15 percent of these high-school graduates also claim some form of post-secondary educational experience. Thus, it would appear that a significant share of the enlistable market would appear to be college-leavers, using the military as an alternative life-style. Like military service, the attrition rate of post-secondary educational institutions is quite high. Data collected on the enrollment status of the high-school class of 1972 and 2 follow-up years are displayed in the following table.

Table 2.10

ENROLLMENT STATUS IN POST-SECONDARY EDUCATION OF
THE HIGH-SCHOOL CLASS OF 1972
(Percent enrolled in post-secondary education)

October 1972			October 1973			October 1974		
White	Black	Hispanic	White	Black	Hispanic	White	Black	Hispanic
56	50	47	47	40	39	39	34	31

Source: U.S. Department of Health, Education, and Welfare, National Center for Education Statistics, National Longitudinal Study of the High School Class of 1972.

According to this survey, approximately 55 percent of the 1972 high-school class continued their education. Two years later the members of this class who were enrolled in school declined to less than 40 percent. Thus, almost a third of those entering post-secondary education failed to complete a full 2 years of enrollment. While some of this decline could be attributed to graduation from 2-year colleges, vocational and technical schools, a good deal of the decline can also be attributed to failure to complete original enrollment plans. The data from the National Longitudinal Study offers corroborative evidence that a sizeable college dropout market exists and that it appears that the Services are already recruiting a significant number from this enlistable segment of the market. Generally speaking, the evidence displayed here shows that the enlistable market of male high-school graduates is somewhat broader than what conventional thinking would lead one to believe.

Chapter 3

METHODOLOGICAL CONSIDERATIONS IN DEVELOPING AN ENLISTMENT SUPPLY MODEL

GENERAL

This chapter discusses the econometric modeling effort aimed at deriving supply models for non-prior service, I-IIIA, diploma high school graduate male enlistees. This is by no means the first work dealing with enlistment supply models, and perhaps a word about the motivation for undertaking yet another supply study is in order.

Two primary considerations made further work appear unavoidable, namely,

- Since sustaining the all volunteer force requires that each individual Service be capable of recruiting a sufficient number of quality personnel to meet its needs, it is necessary to have comparable supply models for each of the four Services, and
- Since the impending population decline is perhaps the largest single obstacle to maintaining the AVF, a Service-by-Service indicator of population impact is called for. Such indicators are not available from previous work.

Additionally, the availability of more reliable population data together with a contemplated methodological improvement (discussed below) offered a reasonable chance of successfully addressing the question of population effects.

THE SUPPLY MODEL

Guidelines for Model Selection

The hypothesis underlying the specification of a supply model is that unintuitive results which have arisen in past studies of enlistment supply arose in large part from data ambiguities and inaccuracies. Accordingly, in specifying the model the following guidelines were observed.

- The unit of analysis and the time period to be considered should be chosen so as to minimize the degree of estimation which must be applied to the source data in order to satisfy the requirements of the model.
- In the absence of an obviously theoretically superior alternative, the functional form of the model should be chosen so as to minimize the distortion induced by uncorrectable defects in the source data.

The Analysis Technique

The supply of quality accessions can be modelled either cross-sectionally for a given time period, or as a time series, or as a combination of the two. Inasmuch as the ultimate objective of this analysis is to predict annual quality accession levels, an annual time-series model is the natural choice. Unfortunately, two distinct considerations diminish the attractiveness of this alternative.

- Paucity of Relevant Data. As the end of the draft was declared in January 1973, only 5 years of AVF data are available for analysis. Consequently, an annual time-series analysis of purely AVF data is not feasible. Due to the vastly different environments offered by the Services during the draft and all-volunteer eras, extension of the annual time-series to include draft era data is an apples-and-oranges proposition warranting considerably less than unqualified acceptance. Disaggregation of the annual series into quarterly or monthly time-series might be expected to produce a reasonable model. It is not clear, however, that a quarterly or monthly model would be appropriate for long-term annual predictions. Because of the relatively small variation in population since the inception of the AVF, no information regarding the impact of population changes can be expected.

- Necessity of Unintuitive and Arbitrary Assumptions. Since population is expected to decrease significantly in the projection period, its effect cannot be ignored. This is true even though, because of little population variability, a population effect cannot be detected by time-series analysis of relevant historical data. The logical result of all this is that some assumption(s) regarding population effects must be made apart from the time-series model.

On the surface, perhaps the most appealing assumption is that for each Service, the decline in quality accessions is proportional to the decline in

quality population. There are no empirical data to support this assumption and there are, in fact, objections to it. Two suggest themselves immediately:

- Quality accessions can be divided into two groups: persons who are contacted by a recruiter and subsequently persuaded to enlist, and persons who contact the recruiter (perhaps after an advertising contact) with some interest in enlisting. Of these two groups, the latter can more probably be thought to vary proportionately with the population (when all other relevant factors remain constant). The situation of the former group is more complex. When the population pool susceptible to enlistment in a Service when actively recruited is larger than can be contacted effectively by the available recruiters, marginal declines in the susceptible population should have little or no effect upon accessions. Only when all the available population is being contacted can accessions be expected to decline proportionately with population.

- Apart from the foregoing considerations, it seems unlikely that the impact of a population decline will be the same on all Services. The pools of persons susceptible to enlistment in the respective Services are probably not of equal size. Certainly, the requirements of the individual Services for quality personnel are not the same. If one Service requires relatively few of the quality personnel in its pool while another Service requires virtually all the quality personnel in its pool, it seems unlikely that the impact of a population decline will be the same for both.

On the basis of the foregoing, it is difficult to see how a pure time-series analysis can account for population effects without arbitrary external assumptions. As the most obvious and plausible assumption regarding population effects seems less than adequate for modelling population impact on the individual Services, some other approach seems desirable.

At this point, there appears to be no alternative to modelling population effects cross-sectionally. A cross-sectional model is possible since population does vary considerably across region and can be seen to have an effect on the number of quality accessions. The obvious question arises as to the appropriateness of using cross-sectional results for the prediction of phenomena through time. There appears to be no definitive resolution of this question in the literature.

Precedents for applying cross-sectional results to time series exist in economics where such application is conventional for demand studies. ^{1/} After over 20 years of debate, however, questions concerning the appropriateness of this technique are still unresolved. That the analysis technique has persisted for so long in the face of criticism indicates that no obviously better alternative has been found.

Other important variables, specifically recruiting effort and unemployment, lend themselves to cross-sectional modelling. For the investigation in hand, a cross-sectional unemployment result is probably superior to a time series result. Such superiority derives from the consensus that cross-sectional unemployment effects are more indicative of the long-term impact of unemployment than effects measured over a relatively short time series.

An important variable which cannot be captured in a cross-sectional analysis is the ratio of military to civilian pay. Consequently, the assumption must be made that the pay ratio remains essentially constant through time. This assumption is probably not too unrealistic.

A pooling of cross-sectional and time series data offers an attractive possibility for overcoming some of the analytical difficulties cited above. This approach ought to be tried. Unfortunately, during this study, only one relevant cross-sectional observation of recruiter distributions was available so no fluctuations through time could be investigated.

The foregoing considerations argue for a cross-sectional modelling effort as the least objectionable feasible approach. Because data for each of the factors of interest can be obtained at the state level without resort to further approximation, the unit of analysis in this study is taken to be the state.

The Time Frame of the Analysis

Since measures of the factors of interest are directly obtainable on an annual basis, the choice of time frame was accordingly limited to the choice of an appropriate calendar or fiscal year. Ultimately, calendar year 1975 was selected as the latest time period for which relevant data were finalized at the state level.

^{1/} J. Johnston, Econometric Methods, McGraw-Hill, New York, 1972, p 164.

The decision to perform the cross-sectional analysis by state for CY75 arose from, and is in accordance with, the first of the guidelines adopted for model selection.

Definition of Variables

The variables selected for the analysis are defined in this section. The various known uncorrectable defects present in the data for each of the variables are included in the presentation, but a discussion of the steps taken to remedy these flaws is deferred until the following section. Source data for the variables are given in Appendix B. Correlation matrices, means, and standard deviations for the variables are presented in Appendix C.

N: Quality Accessions: The dependent variable sought for the analysis is the number of quality accessions accruing to the respective Services in CY75. A fundamental assumption of the analysis is that this group is supply-limited, i.e., that the number of quality accessions is limited by the supply of such persons who can be induced to join the military rather than by the military's demand. In the analysis, this group is defined to be non-prior service, diploma high school graduate, 17-21-year-old males classified in mental categories I-IIIA.

The accession data for all Services were obtained from magnetic tape files provided by the United States Army Recruiting Command (USAREC). Accession data for the Army, Navy and USAF, although at odds with monthly reports published by USAREC (i.e., Supplemental Enlistment Option Report) are presumed to be correct. Approximately 17 percent of the USMC accession records were unusable because missing education codes prohibited high school graduate classification.

Q: Quality Population. The population variable is defined to be the non-prior service, diploma high school graduate, 17-21-year-old males classified in mental categories I-IIIA and not pursuing further schooling. Nationally, this subpopulation accounts for approximately 6 percent of the Military Available (MA) population. (The MA population is taken to be non-prior service, non-institutionalized, 17-21-year-old males.) Data for this variable were extracted from GRC estimates of Qualified Military

Available (QMA) population as of June 1976. (The QMA population is that segment of the MA population which is both physically and mentally qualified for military service.)

R: Recruiters on Station. The recruiter data used in this analysis were provided by USAREC with the concurrence of representatives of the individual Services. The data consist of estimates of production recruiters (including area captains) on station as of 31 October 1976. These are the only state-level estimates of recruiter strengths available.

U: Unemployment. Unemployment is a traditional measure of economic condition. In this analysis, the underlying economic data are extracted from Table D-4, "Total Unemployment and Unemployment Rates by State: Annual Averages, 1970-75" of the Employment and Training Report of the President, transmitted to the Congress, 1976. The data represent general unemployment as a percent of the labor force and were provided by state employment security agencies cooperating with the U.S. Department of Labor.

E: Reciprocal of Civilian Pay. In order to account for regional variation in economic attractiveness of military service as an alternative to civilian pursuits, the reciprocal of civilian pay was included in the model. The data for this variable were extracted from Table C-13, "Gross hours and earnings of production workers on manufacturing payrolls, by state and selected areas" of the Bureau of Labor Statistics publication, Employment and Earnings, for August 1976. The payroll data are for June 1976.

The justification for including regional variations in civilian pay scales in the analysis is based upon two considerations. First, it appears plausible that certain of the economic and career motivations for entering military service (e.g., learning a trade) are influenced by socioeconomic status. Secondly, the attractiveness of military pay is undoubtedly modified by prevailing civilian pay scales.

Since military pay is constant across region, a cross-sectional model cannot track its effect and hence military pay is not considered in this analysis. Customarily, when military pay appears in a time-series analysis,

it is included as the ratio of military to civilian pay. It is this traditional treatment of civilian pay which led to the decision to include its reciprocal in the analysis.

Selection of a Functional Form

In accordance with the second guideline for model selection, the functional form chosen for the analysis is the multiplicative Cobb-Douglas form, viz,

$$N = e^c Q^{\epsilon_q} R^{\epsilon_r} U^{\epsilon_u} E^{\epsilon_e}$$

where N , Q , R , U and E are as defined above,

e (≈ 2.7183) is the base of the natural logarithms, and c , ϵ_q , ϵ_r , ϵ_u , ϵ_e are parameters to be determined by fitting the functional forms to the available data.

The parameters ϵ_q , ϵ_r , ϵ_u , ϵ_e are the elasticities of the associated variables. The elasticity is defined to be the percentage change induced in the dependent variable by a percent change in the associated independent variable (if, for example, the elasticity of population is equal to .5, a 10 percent change in Q would induce a 5 percent change in N).

The Cobb-Douglas form is chosen for the analysis primarily because of a property unique to it, viz, the elasticities computed from the model are invariant under simple scaling of the variables. This property may be illustrated by considering the following example. Suppose that Y can be expressed as a function of X in the following way:

$$Y = c X^{\epsilon_x}$$

If the model is recast to write Y as a function of $Z = kX$ where k is a positive number, the property of invariant elasticities under scaling of the data means that the solution to the new model is

$$Y = c' Z^{\epsilon_x}$$

where $c' = c/k^{\epsilon_x}$. Although the value of the constant term is different for the two models, the elasticities for the scaled and unscaled variables are identical.

The impact of the property of invariant elasticity under scaling is important in view of the uncorrectable defects in the source data. Specifically,

- Although the accession data for the Army, Navy and Air Force are presumed to be reasonably complete and correct, 17 percent of the USMC accession records were unusable due to missing education codes. To the extent that the high school graduates represented by these records were proportionately distributed among the states, no distortion is induced in the elasticities arising from the Marine Corps model.

- With respect to the population variable Q, it is noted that if the "true market" for a service is proportional to Q, the elasticity computed for Q will be the "true market" elasticity for the service. Furthermore, the QMA data from which Q is developed is reported as of June 1976. The assumption that the 1975 QMA is proportional to the 1976 QMA is quite reasonable and thus the use of the Cobb-Douglas form prevents the difference in magnitudes from distorting the elasticity computed for Q.

- As stated in the definition of R, the only estimates of recruiter strengths by state are made as of 31 October 1976. To the extent that the distribution of recruiters among the states (1.4 percent of the recruiter force in Alabama, 10.6 percent in California, etc.) in CY75 coincides with the distribution as of 31 October 1976, the elasticity computed for R will be free from distortion.

- The overall unemployment rate U is intended as a measure of general economic condition. If a measure of more direct motivation to enlist were desired, the unemployment rate among the age and race groups of interest might be considered. To the extent that these specific unemployment rates are proportional to overall unemployment, the elasticity computed for U will be the elasticity for the specific rates.

- E is intended as a measure of regional economic opportunity in the civilian sector. Average earnings for production manufacturing workers were chosen for the computation of this variable but, as discussed above, any pay scale proportional (across states) to total manufacturing wages will yield an elasticity identical to that of E.

In light of the above discussion, it is evident that the property of invariant elasticities under scaling mitigates as far as possible the distortion effects of the uncorrectable defects in the source data and hence provides the Cobb-Douglas function with a robustness which is lacking in other (specifically linear) functional forms.

Methodological Considerations

The methodological price paid for the robustness of the Cobb-Douglas form is the loss of linearity. The customary treatment of this difficulty is to resort to a logarithmic transformation, viz,

Multiplicative model:

$$N = e^c (Q^{\varepsilon_q})(R^{\varepsilon_r})(U^{\varepsilon_u})(E^{\varepsilon_e})$$

Log-linear model:

$$\ln(N) = c + \varepsilon_q \ln(Q) + \varepsilon_r \ln(R) + \varepsilon_u \ln(U) + \varepsilon_e \ln(E)$$

where $\ln(X)$ represents the natural logarithm of X and all other terms are as defined above. Having constructed the log-linear model, the customary practice is to solve it for c , ε_q , ε_r , ε_u , ε_e using a standard linear regression package and take ε_q , ε_r , ε_u and ε_e to be the elasticities of the corresponding variables.

The above described approach is not correct. The problem lies in the unfortunate fact that since the logarithm is not a linear transformation, the solution of the log-linear model is not the solution of the multiplicative model. (This problem is discussed at some length in an article by W. A. Dotson in Appendix A.)

The methodology used in this study is to construct and solve the log-linear model in the ordinary way and then use the computed parameters as a starting point for the iterative solution of the multiplicative model. The computer routine used for the nonlinear solution is a Gauss-Marquardt least-squares algorithm written at the Computing Technology Center, Union Carbide Corp., Nuclear Division, Oak Ridge, Tennessee, by G. W. Wesley and modified at North Carolina State University by R. M. Felder.

- Remove statistically insignificant variables from the solution (i.e., constrain the associated elasticity to be zero) first singly and then in pairs until a model results in which all non-zero elasticities are statistically significant. This step yields the finalized models.

Preliminary Solutions (Log-linear vs Multiplicative)

The solution and associated R^2 for each of the log-linear models and for each of the preliminary multiplicative models are presented in Table 4.1.

The differences between the log-linear and multiplicative models are sometimes quite striking. Special attention is drawn to the significant differences between unemployment elasticities computed for non-whites in the Army and Navy models. These and other differences serve to illustrate the fact that approximate solutions, however time-honored, need not be very good approximations.

Finalized Solutions

Finalizing the supply models is a matter of assigning the statistically insignificant variables an elasticity of zero and resolving the model. This procedure effectively removes the non-significant variables from the supply equation. In the equations with two insignificant variables, models were considered where each of the variables was removed separately and where both variables were removed at once. This procedure guarantees that no statistically significant variable of the set under consideration was omitted because of noise arising from the presence of an insignificant variable.

The finalized supply models are presented in Table 4.2, along with the standard error for each elasticity.

DISCUSSION OF RESULTS

Population (QMA) and Recruiters

Examination of the correlation matrices of Appendix C reveals a high correlation between recruiters on station and QMA. Since QMA has historically been the basis for recruiter assignment, this correlation is not

Table 4.1
I-IIIA, DHSG ACCESSION SUPPLY ELASTICITIES ARISING FROM
LOG-LINEAR MODEL (L) AND MULTIPLICATIVE MODEL (M)

		White		<u>Non-white</u>	
		<u>L</u>	<u>M</u>	<u>L</u>	<u>M</u>
	c	-1.19	4.50	16.24	22.41
	ϵ_q	.57	.65	.89	.41
	ϵ_r	.30	.34	.30	.54
Army	ϵ_u	.44	.34	.52	-.42
	ϵ_e	-.07*	1.16	3.73	4.11
	R ²	.9282	.9624	.5581	.7505
<hr/>					
	c	-1.24	3.50	6.80	7.02
	ϵ_q	.52	.44	.34	.35
	ϵ_r	.34	.56	.70	.63
Navy	ϵ_u	.19	.03*	.17*	-.53
	ϵ_e	-.26	.61	1.49	1.18
	R ²	.9275	.9679	.8954	.9310
<hr/>					
	c	-.30	1.49	11.25	6.44
	ϵ_q	.54	.17	.78	.65
USAF	ϵ_r	.40	.75	.48	.22
	ϵ_u	.50	.25	.17*	-.20*
	ϵ_e	.10*	-.11*	2.63	1.19
	R ²	.9318	.9496	.7340	.8767
<hr/>					
	c	-5.68	-1.30	12.52	5.61
	ϵ_q	.78	.53	.75	.56
	ϵ_r	.15	.40	.32	.27
USMC	ϵ_u	.26	-.06*	.47	-.15*
	ϵ_e	-.61	-.18*	2.94	1.05
	R ²	.9322	.9583	.7399	.8251

* Indicates that the parameter is not statistically significant.

Table 4.2
FINALIZED SUPPLY MODELS FOR I-IIIA, DHSG ACCESSIONS

Parameter	White		Non-white	
	Value	Standard error	Value	Standard error
c	4.50		22.41	
ϵ_q	.65	.10	.41	.15
ϵ_r	.34	.09	.54	.20
Army ϵ_u	.34	.11	-.42	.41 ^{a/}
ϵ_e	1.16	.24	4.11	.56
R ²	.9624		.7505	
c	3.54		7.02	
ϵ_q	.44	.07	.35	.08
ϵ_r	.56	.06	.63	.08
Navy ϵ_u	-0-		-.53	.19
ϵ_e	.61	.23	1.18	.32
R ²	.9678		.9310	
c	1.85		5.99	
ϵ_q	.20	.09	.64	.08
ϵ_r	.73	.09	.21	.08
USAF ϵ_u	.25	.12	-0-	
ϵ_e	-0-		1.17	.37
R ²	.9495		.8755	
c	-.76		5.31	
ϵ_q	.57	.09	.55	.10
USMC ϵ_r	.37	.08	.26	.10
ϵ_u	-0-		-0-	
ϵ_e	-0-		1.04	.45
R ²	.9579		.8243	

^{a/} While this elasticity only just barely satisfies our condition for significance, the primary reason for not ignoring it is that the corresponding standard error for the regression against mental group I and II accession was only one-fourth as large for virtually the same value of ϵ_u .

surprising. Still, a question occurs as to the reliability with which the model discriminates between the effects of population and recruiters. To date, the theoretical development required to resolve this question in the case of the non-linear form of model chosen for the analysis has not been done. In the absence of a rigorous method of evaluating precisely how deleterious the large correlations are, the properties of the modeling results must be closely examined. To facilitate this examination, the finalized population and recruiter elasticities are summarized in Table 4.3.

Table 4.3

SUMMARY OF THE FINALIZED ELASTICITIES FOR
POPULATION (ϵ_q) AND RECRUITERS (ϵ_r) BY RACE AND SERVICE

Service	White			Non-white		
	ϵ_q	ϵ_r	$\epsilon_q + \epsilon_r$	ϵ_q	ϵ_r	$\epsilon_q + \epsilon_r$
Army	.65	.34	.99	.41	.54	.95
Navy	.44	.56	1.00	.35	.63	.98
USAF	.20	.73	.93	.64	.21	.85
USMC	.57	.37	.94	.55	.26	.81

$\epsilon_q + \epsilon_r \approx 1$. The results show that for each of the eight models, the sum of the population and recruiting elasticities is very near unity. This result derives empirically from the nature of the data rather than from any constraint in the model. It can be taken, therefore, to be strong empirical support for an alternative formulation in which population and recruiting elasticities sum to unity by assumptions, i.e.,

$$\epsilon_q + \epsilon_r = 1.$$

Under this assumption the model

$$N = cQ \frac{\epsilon_q}{R} \frac{\epsilon_r}{U} \frac{\epsilon_u}{E} \frac{\epsilon_e}{E}$$

can be rewritten as

$$\left(\frac{N}{R}\right) = c \left(\frac{Q}{R}\right) \frac{\epsilon_q}{U} \frac{\epsilon_u}{E} \frac{\epsilon_e}{E}$$

where ϵ_q is the same for both formulations and where all other variables are as defined above. Thus, the empirically-derived assumption that population and recruiting elasticities sum to unity is equivalent to assuming a Cobb-Douglas form where the elasticity of population coverage ($\frac{Q}{R}$) with respect to recruiter productivity ($\frac{N}{R}$) is ϵ_q . It is noteworthy that this alternate formulation eliminates the difficulty of a high correlation between recruiters and population.

Had this alternate formulation been employed at the outset, the resulting models would have (with few exceptions) been virtually identical to those summarized in Table 4.3.

Results Not Unintuitive. Since a time series approach was considered in Chapter 3 and rejected because of its unintuitive implications regarding population effects, the alternative model used in this analysis should be examined for the same shortcoming.

Presuming no change in other factors, if the recruitable population for a Service is saturated with recruiters (virtually every recruitable person is being contacted by a recruiter), then the size of the available population is the controlling factor and the addition of more recruiters can be expected to have little effect. This situation produces a high population elasticity and a low recruiter elasticity. On the other hand, if relatively few of the Service's recruitable population are being contacted, the addition of more recruiters can be expected to have almost a proportional effect whereas the effect of changing the recruitable population would be relatively small.

According to this simple model, the more attractive a service is (the larger its recruitable population), the smaller its population elasticity will be and the larger its recruiter elasticity will be. Similarly, the less attractive a service is, the larger its population elasticity will be and the smaller its recruiter elasticity will be. The population and recruiter elasticities shown in Table 4.3 do not appear to be badly at variance with either these expectations nor general recruiting experience. In the absence of other contradictory evidence, there seems to be no compelling reason to reject the population and recruiter elasticities arising from the cross-sectional supply models.

Unemployment

The unemployment variable used in this analysis is intended as a measure of the effect upon enlistments of the general economic condition. (A time-series analysis is required in order to address the direct, short-term impact of changes in unemployment rate.) It is presumed that areas with higher unemployment rates have fewer opportunities to offer in the civilian sector, and that consequently the alternative of military service is relatively more attractive than it is in areas where more civilian opportunities exist. Accordingly, one would expect ϵ_u to be non-negative.

With reference to the finalized supply models of Table 4.2, two facts are noteworthy:

Unemployment elasticities for whites are non-negative. The zero elasticities for the Navy and Marine Corps models mean that no evidence exists within the framework of these supply models to indicate that Navy and Marine Corps enlistments are much affected by regional variation in unemployment. The phenomenon suggests that white persons motivated by limited civilian opportunities prefer enlistment in the Army or Air Force to enlistment in the Navy or Marine Corps.

Unemployment elasticities for non-whites are non-positive. Again, zero elasticities for the Air Force and Marine Corps models suggest that regional economic condition is not an important motivation for non-white accessions to these services. The more significant result is the negative unemployment elasticities of the Navy (and, less strongly, the Army as well). In a time-series analysis, this phenomenon would indicate a substitution effect, i.e., during periods of high unemployment, white accessions are more readily available and are preferred (through policy considerations) to non-white accessions. The result is that fewer non-white accessions are produced than would be expected under the prevailing unemployment rate. This negative impact of high unemployment upon non-white enlistments (and the corresponding positive impact of low unemployment rates) results in a negative unemployment elasticity. Although this rationale may explain the negative values of ϵ_u for the Army and Navy models, certain objections arise:

- The cross-sectional model does not consider the effect of unemployment in different periods but rather the effect of unemployment in different regions. Consequently, it is conceivable that the effect of unemployment is being distorted by some regional phenomenon not otherwise accounted for by the model.
- In the light of the Services' quality requirements, if representational problems or other policy considerations were causing a substitution effect, it seems reasonable that the substitution would be of higher quality whites and non-whites for lower quality non-whites. This substitution mechanism would produce non-negative unemployment elasticities for the quality non-white enlistments under consideration.
- Because of the relatively small number of non-white accessions from some states and a corresponding small non-white population, the results of the non-white models may be distorted by sample size considerations. This possibility warrants further investigation.

If a substitution phenomenon such as described earlier for the hypothetical time series were operating in the Army and Navy, the effect in the cross-sectional model would presumably be just that which was observed. Nevertheless, it is illogical to conclude solely from these supply results that such a phenomenon is operating. The models indicate that for non-whites some external factor or factors are interfering with the ordinary supply mechanism. It is not possible to positively identify any such factors on the basis of this cross-sectional analysis.

Additional research is recommended on unemployment effects, including use of race-specific unemployment data as well as youth unemployment data, to supplement the present analysis which used overall unemployment data.

Compensation

The pay variable is included in the model to account for variation in the attractiveness of military pay due to differences in the civilian pay scale. In light of the historical fact that civilian wage opportunities for non-whites are substantially less than for whites, it is not surprising that this variable is substantially more important in the supply models for non-whites than it is in the white supply models. The fact that ϵ_e is

significantly larger for the Army than for the other Services suggests that wage opportunity is a more significant factor in the enlistment decision for the Army than it is for the other Services. It should be noted, however, that ϵ_e says nothing in a direct way about the impact of military pay scales.

Developing the DOD Composite Supply Model

It is not possible, using the methodology employed in this study, to state categorically that the supply of volunteers to each Service is mutually exclusive. Obviously, there is considerable overlap in the recruiting market for each of the Services. This study does point out, however, that there are significant differences when the parameters of enlistment supply are examined by race. Based on this evidence, it was decided that forecasts of total enlistments should be derived by combining the separate estimates of the white and non-white supply models. To a lesser extent, the evidence also suggests that the quality enlistment supply to the individual Services is independent of each other, i.e., the degree of sensitivity of Navy enlistment supply to specific parameters is significantly different from the degree of sensitivity of Army enlistment supply to these same parameters.

Essentially, this means that it is not correct to combine all enlistment groups (both race- and Service-specific) and use this as the dependent variable in an attempt to forecast aggregate DOD enlistment supply. A more correct way is to estimate supply for each of the groups independently and then aggregate supply forecasts to obtain a DOD estimate.

While actual enlistment forecasts are derived in this manner, it may also be helpful to have aggregated elasticities and productivities of the various parameters used in the enlistment supply models. Table 4.2 displays the supply parameters computed independently by Service and race. Where elasticities are required that are not race-specific and/or Service-specific, these elasticities should be computed as a composite value of the race- and Service-specific elasticities, weighted by the proportion of enlistments obtained by race and Service. The method for computing these elasticities is demonstrated in the example on the following page.

Using this methodology, Table 4.4 shows the non-race-specific elasticities for each of the parameters by Service and for DOD,

Let T = total enlistments,
 W = white enlistments,
 B = non-white enlistments,
 ϵ_{r_T} = composite elasticity for recruiters without regard to race.

Then,

$$\begin{aligned}
 \epsilon_{r_T} &= \frac{\Delta T}{T} / \frac{\Delta R}{R} = \frac{\Delta T}{\Delta R} \cdot \frac{R}{T} \\
 &= \frac{\Delta W + \Delta B}{\Delta R} \cdot \frac{R}{T} \\
 &= \frac{\Delta W}{\Delta R} \cdot \frac{R}{T} + \frac{\Delta B}{\Delta R} \cdot \frac{R}{T} \\
 &= \frac{W}{W} \left(\frac{\Delta W}{\Delta R} \cdot \frac{R}{T} \right) + \frac{B}{B} \left(\frac{\Delta B}{\Delta R} \cdot \frac{R}{T} \right) \\
 &= \frac{W}{T} \left(\frac{\Delta W}{\Delta R} \cdot \frac{R}{W} \right) + \frac{B}{T} \left(\frac{\Delta B}{\Delta R} \cdot \frac{R}{B} \right) \\
 &= \frac{W}{T} \epsilon_{r_w} + \frac{B}{T} \epsilon_{r_b} .
 \end{aligned}$$

For the Army models, the expression for composite recruiter elasticity evaluates as follows:

$$\begin{aligned}
 \epsilon_{r_T} &= \frac{47,848}{55,994} (.34) + \frac{8,146}{55,994} (.54) \\
 &= .856(.34) + 1.44(.54) \\
 &= .29 + .078 = \underline{.368}
 \end{aligned}$$

Table 4.4

NON-RACE-SPECIFIC SUPPLY MODELS FOR I-III A DHSG ENLISTMENTS
 (Values shown in the table represent elasticities)

Parameter	Army	Navy	Marine Corps	Air Force	DOD		
					White	Non-white	Total
Constant	7.11	3.81	.12	2.26	2.88	12.82	4.01
ϵ_q	.62	.43	.57	.24	.46	.47	.46
ϵ_r	.37	.57	.35	.68	.51	.44	.50
ϵ_u	.23	-.04	-0-	.23	.17	-.28	.12
ϵ_e	1.59	.65	.15	.12	.55	2.36	.76

While it is more nearly correct to forecast enlistments by race and Service and then aggregate the data to obtain a combined forecast, use of the elasticities shown on Table 4.4 will provide estimates comparable to the preferred approach. In a later chapter in this report, the composite recruiter elasticities are used to estimate the size of the accession budget required to offset projected declines in enlistments.

Chapter 5

ENLISTMENT PROJECTIONS

GENERAL

The forecasts of quality enlistments presented in this chapter are developed from the race-specific enlistment supply models summarized in Table 4.2. The forecasts examine the effects of projected changes in populations and unemployment rates as documented by the Census Series II projections of the 17-21-year-old male populations by race^{1/} and the Congressional Budget Office (CBO) projections of unemployment rates^{2/}.

RESULTS

Tables 5.1, 5.2 and 5.3 display the yearly changes in quality enlistments anticipated due to population shifts or CBO's projected decline in unemployment.

Table 5.1 displays the projected changes in supply, assuming CBO's October 1976 unemployment projections. This projection assumes no change in population. This unemployment projection was based upon a more optimistic outlook for improvements in the economy. CBO forecasted that unemployment would decline approximately 52 percent and reach a 4 percent level by 1983.

Table 5.2 displays the expected changes in enlistments, assuming CBO's January 1977 unemployment projections. Under this projection, CBO forecasts a more gradual recovery in the economy and a general unemployment decline by some 45 percent by 1983. Note that the budget analysis conducted in this report uses CBO's January unemployment projections. The enlistment projections using the October 1976 CBO forecast are included here for comparison purposes only.

^{1/} Current Population Reports, series P-25, No. 601, Bureau of the Census, October 1975.

^{2/} "The Costs of Defense Manpower: Issues for 1977," Budget issue paper prepared by the Congressional Budget Office, January 1977, Tables A-1 and A-2.

Table 5.1

PROJECTED CUMULATIVE PERCENT CHANGES IN I-IIIA, DMSG ACCESSIONS BY RACE AND SERVICE UNDER OCTOBER 76 UNEMPLOYMENT PROJECTIONS

Army	NAVY		USAF		USMC	
	White	Non-white	White	Non-white	White	Non-white
1976	-.0238	+.0294	-0-	+.0371	-.0175	-0-
1977	-.0578	+.0714	-0-	+.0901	-.0425	-0-
1978	-.0918	+.1134	-0-	+.1431	-.0675	-0-
1979	-.1190	+.1470	-0-	+.1855	-.0875	-0-
1980	-.1428	+.1764	-0-	+.2226	-.1050	-0-
1981	-.1564	+.1932	-0-	+.2438	-.1150	-0-
1982	-.1700	+.2100	-0-	+.2650	-.1250	-0-
1983	-.1768	+.2184	-0-	+.2756	-.1300	-0-
1984	-.1768	+.2184	-0-	+.2756	-.1300	-0-
1985	-.1768	+.2184	-0-	+.2756	-.1300	-0-
1986	-.1768	+.2184	-0-	+.2756	-.1300	-0-

PROJECTED CUMULATIVE CHANGE IN I-IIIA, DMSG ACCESSIONS BY RACE AND SERVICE UNDER OCTOBER 76 UNEMPLOYMENT PROJECTIONS

Army	NAVY		USAF		USMC	
	White	Non-white	White	Non-white	White	Non-white
1976	-1139	+.239	-900	-0-	+.153	-.697
1977	-2766	+.582	-2284	-0-	+.371	-.1693
1978	-4393	+.924	-3469	-0-	+.589	-.2689
1979	-5694	+.1197	-4497	-0-	+.764	-.3485
1980	-5833	+.1437	-4396	-0-	+.917	-.4182
1981	-7484	+.1574	-5910	-0-	+.1004	-.4581
1982	-8134	+.1711	-6423	-0-	+.1091	-.4979
1983	-8460	+.1779	-6681	-0-	+.1135	-.5178
1984	-8460	+.1779	-6681	-0-	+.1135	-.5178
1985	-8460	+.1779	-6681	-0-	+.1135	-.5178
1986	-8460	+.1779	-6681	-0-	+.1135	-.5178

Table 5.2

Projected Cumulative Percent Changes in I-IIIA, DHSG Accessions by Race and Service Under January 77 Unemployment Projection

	ARMY		NAVY		USAF		USMC	
	White	Non-White	White	Non-White	White	Non-White	White	Non-White
1976	.0000	+.0000	-0-	.0000	.0000	-0-	-0-	-0-
1977	-.0238	+.0294	-0-	+.0371	-.0175	-0-	-0-	-0-
1978	-.0442	+.0546	-0-	+.0689	-.0125	-0-	-0-	-0-
1979	-.0578	+.0714	-0-	+.0901	-.0425	-0-	-0-	-0-
1980	-.0850	+.1050	-0-	+.1325	-.0625	-0-	-0-	-0-
1981	-.1088	+.1344	-0-	+.1696	-.0800	-0-	-0-	-0-
1982	-.1326	+.1638	-0-	+.1802	-.0850	-0-	-0-	-0-
1983	-.1530	+.1890	-0-	+.2385	-.1125	-0-	-0-	-0-
1984	-.1530	+.1890	-0-	+.2385	-.1125	-0-	-0-	-0-
1985	-.1530	+.1890	-0-	+.2385	-.1125	-0-	-0-	-0-
1986	-.1530	+.1890	-0-	+.2385	-.1125	-0-	-0-	-0-

Projected Cumulative Change in I-IIIA, DHSG Accessions by Race and Service Under January 77 Unemployment Projections

ARMY	NAVY		USAF		USMC	
	White	Non-White	Total	White	Non-White	Total
1976	0	0	0	0	0	0
1977	-1119	+.239	-900	+.153	+.153	0
1978	-2115	+.445	-1670	+.284	+.284	-697
1979	-2766	+.582	-2184	+.371	+.371	-1295
1980	-4067	+.855	-3212	+.546	+.546	-1693
1981	-5206	+.1095	-4111	+.698	+.698	-2489
1982	-6345	+.1334	-5011	+.742	+.742	-3186
1983	-7321	+.1540	-5781	+.982	+.982	-3386
1984	-7321	+.1540	-5781	+.982	+.982	-4481
1985	-7321	+.1540	-5781	+.982	+.982	-4481
1986	-7321	+.1540	-5781	+.982	+.982	-4481

Table 5.3

Projected Cumulative Percent Changes in I-IIIA, DISG Accessions Due to Population by Race and Service

ARMY	NAVY			USAF			USMC		
	White		Non-white	White		Non-white	White		Non-white
	White	Non-white	White	Non-white	White	Non-white	White	Non-white	White
1976	+.00650	+.01230	+.00440	+.01050	+.00200	+.01920	+.00570	+.01650	
1977	+.01040	+.02132	+.00700	+.01220	+.00320	+.03128	+.00912	+.02860	
1978	+.01560	+.02911	+.01056	+.02485	+.00480	+.04544	+.01368	+.03905	
1979	+.01300	+.03362	+.00880	+.02870	+.00400	+.05248	+.01140	+.04510	
1980	+.00845	+.01813	+.00572	+.03255	+.00260	+.05952	+.00741	+.05115	
1981	+.00260	+.04100	+.00176	+.03500	+.00080	+.06400	+.00228	+.05500	
1982	-.00910	+.04223	-.00616	+.03605	-.00280	+.06592	-.00798	+.05665	
1983	-.06175	+.03977	-.04160	+.03995	-.01900	+.06208	-.05415	+.05335	
1984	-.08320	+.03321	-.05632	+.02315	-.02560	+.05184	-.07296	+.04455	
1985	-.10595	+.02624	-.07172	+.02240	-.03260	+.04096	-.09291	+.03320	
1986	-.12610	+.02132	-.08536	+.01820	-.03880	+.013328	-.11058	+.02860	

Projected I-IIIA, DISG Accessions Under Population Changes by Race and Service

ARMY	NAVY			USAF			USMC		
	White		Total	White	Non-white	Total	White	Non-white	Total
	White	Non-white	Total	White	Non-white	Total	White	Non-white	Total
1976	4,8160	8246	56406	48343	4161	52504	39911	4469	44380
1977	4,8346	8320	56666	48668	4193	52661	39958	4531	44489
1978	4,8595	8383	56978	48639	4220	52059	40022	4584	44606
1979	4,8471	8420	56891	48555	4236	52791	39990	4615	44605
1980	4,8253	8457	56710	48406	4252	52658	39935	4646	44581
1981	4,7973	8480	56453	48216	4262	52478	39863	4666	44529
1982	4,7414	8490	55904	47835	5201	5174	39719	4674	44393
1983	4,4894	8470	53364	46119	4258	50377	39074	4657	43831
1984	4,1868	8417	52285	45420	4235	49655	38811	4612	43423
1985	4,2779	8360	51139	44679	4210	48889	38533	4565	43098
1986	4,1815	8320	50135	44023	4193	48286	4531	42817	42817

In examining Table 5.2, it is apparent that, based on the supply models developed in Chapter 4, no unemployment effects for this quality class were detected for the Marine Corps. Significant unemployment effects were found for both whites and non-whites in the case of the Army supply model only. In the case of Army white enlistments, a decline of up to 15 percent is expected by 1983. In contrast, Army non-white enlistments should rise by 19 percent in 1983. Numerically, this amounts to 7300 white enlistments lost and 1500 non-white enlistments gained by the Army by 1983. With respect to the Navy, no change in white enlistments is anticipated since the model did not detect a significant unemployment effect for this quality class. Non-white enlistments were expected to increase by some 24 percent by 1983. The numerical increase, however, is rather small — less than 1000 additional enlistments. For the Air Force, white enlistments are expected to decrease slightly more than 11 percent by 1983, or a numerical decline of approximately 4500 enlistments. No decrease in non-white enlistments is projected.

Table 5.3 displays the projections due to anticipated changes in the population of 17-21-year-old males. This projection assumes no change in unemployment. Note that based on census population forecasts and the results of the supply model developed in Chapter 4, declines in enlistments for this quality class are anticipated for white males only. This decline does not actually begin until 1982. If these assumptions are correct, non-white enlistments in the preferred quality class will continue to rise for all Services.

Of the four Services, the Army is most sensitive to changes in population. By 1986, Army white enlistments should be 13 percent below the CY 1975 estimates; thus, white enlistments will decline from approximately 48,000 to 42,000. Because a slight increase in non-white enlistments is anticipated, the net decline for this quality enlistment group is expected to be slightly more than 11 percent by 1986.

The Census projections also show that the white male population will continue to decline through the 1990's. The trough of this decline is expected to be in 1993 when the white male population of those 17-21-years old will be 32 percent below the level for 1975. Should the QMA of this

group decline proportionately, the elasticities developed in Chapter 4 would project a 21 percent decline in Army white enlistments in the preferred quality class. The other Services would also experience declines, although to a lesser degree in both relative and absolute terms.

GRC has assumed that there is a proportional relationship between annual changes in the 17-21-year-old male population and male QMAs of this age group who are also diploma high school graduates and in mental groups I-III A.

In evaluating current and future enlistment potential, the size of the QMA market is an important consideration; for example, Table 5.4 displays QMA and enlistment data to produce a measure of market penetration achieved by the Services. Overall, the Services are recruiting about 9 percent of the diploma high school graduate QMA market (mental groups I-IV). While 9 percent may not appear to be a sizable proportion of the total market, when disaggregated by race and mental group, significant differences in market penetration do appear. For example, with respect to the non-white, I-III A QMA market, almost 47 percent of that market is already enlisting in the military. In contrast, the proportion of the white I-III A QMA market enlisting is approximately 9 percent, or less than one-fifth the rate of enlistment when compared to non-whites. Results such as these are consistent with survey data which show significant differences in preference for the military when the data are examined by race. More important, however, is the fact that the Services are already recruiting a very sizable share of the non-white enlistment market. Unless there are dramatic improvements in the mental group distribution or high school completion rates of minorities, it is unrealistic to expect a substantial increase in non-white enlistments in the future in spite of the fact that the population for this group will continue to grow through the 1980's. This conclusion, however, should be tempered with the following considerations. First, while the non-white QMA market amounts to less than 200,000 in total, over three-fourths of this group fall into mental groups III B and IV (Figure 5.1). Presumably, the lower market penetration for these non-whites is due to the enlistment qualification standards currently in effect. Should the Services find themselves in the position of needing more high school graduates in the future, a decision

Table 5.4
RECRUITING MARKET PENETRATION

	(1) Diploma high school graduate QMA market	(2) DOD Male DHSG enlistments (CY75)	(2÷1) Market penetration (percent)
<u>White</u>	<u>2,575,506</u>	<u>205,253</u>	<u>8.0</u>
I, II	1,322,366	97,409	7.4
IIIA	486,084	57,362	11.8
IIIB	462,233	42,665	9.2
IV	304,823	7,817	2.6
 <u>Non-white</u>	<u>198,894</u>	<u>45,535</u>	<u>22.9</u>
I, II	19,871	7,761	39.1
IIIA	22,639	12,122	53.5
IIIB	56,417	19,412	34.4
IV	99,967	6,240	6.2

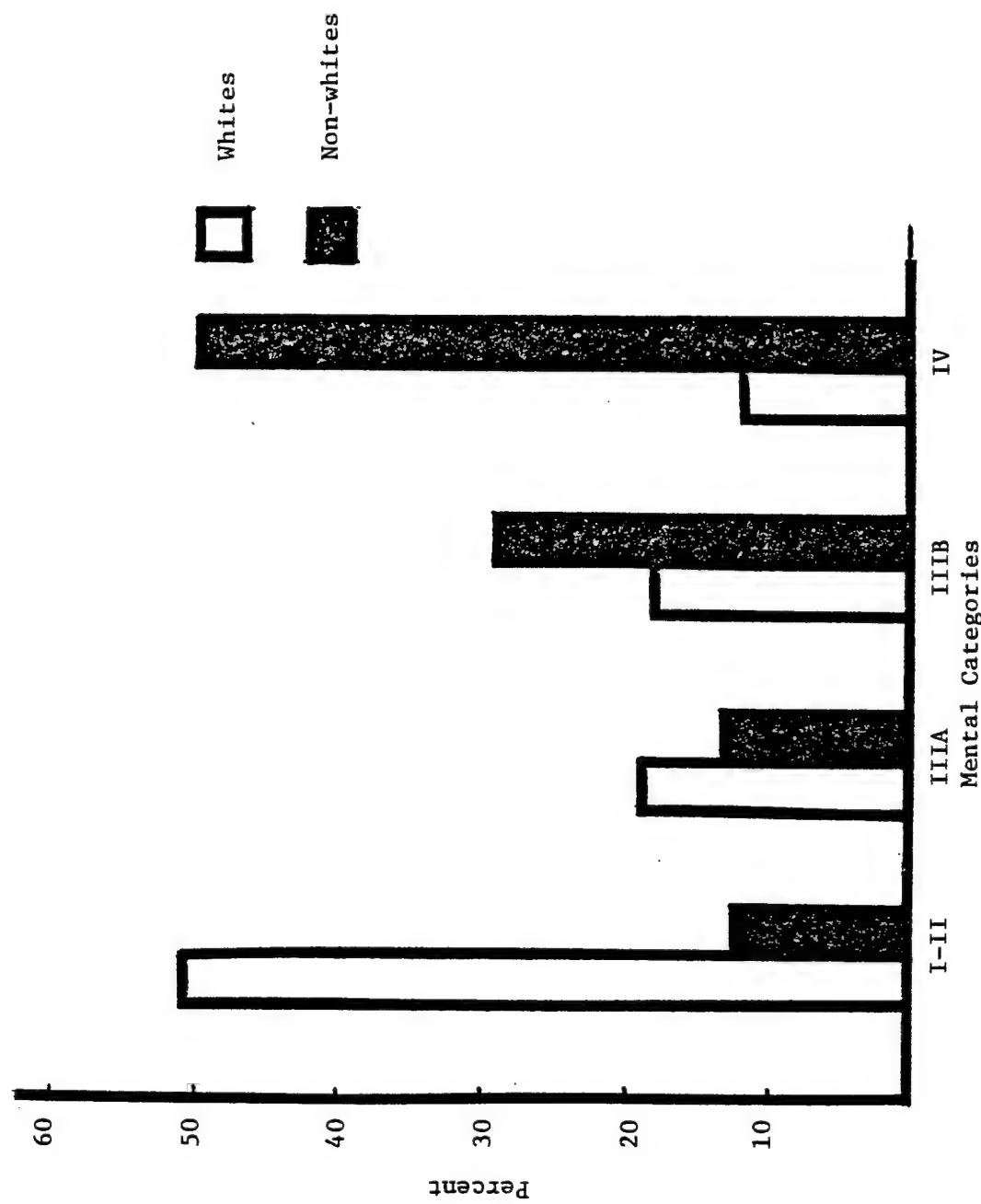


Fig. 5.1—17-21-year-old QMA Male High-School Graduates
Mental Group Distribution by Base

to recruit from the lower mental groups would substantially increase minority enlistments; for example, if administrative controls on recruiting IIIB QMAs were dropped, a proportion of minority QMAs recruited from this group would likely rise from the current 34 percent. This action alone could bring in an additional 7,000 male high school graduate enlistments, which would almost equal the projected decline in white high school graduate enlistments in mental groups I-IIIA due to population changes through 1986.

Additionally, both the QMA and the Census population projections are subject to sampling error. Baseline data used in the QMA projections are Census population data and, therefore, to the extent that Census population data are inaccurate, similar inaccuracies will have crept into the QMA data. One criticism that has been raised regarding Census data is the potential undercount of minority populations during the 1970 census. Indirect estimates of the current minority populations suggest that the undercount is of a magnitude approaching 10 percent. If an undercount exists, then projected minority recruitment in the future is understated.

Table 5.5 displays the numerical projections arising from the analysis. Base supply estimates are CY 1975 actual counts and are displayed on Table 5.6. This table also shows enlistment counts for lower mental group personnel, as well as data on the QMA market.

It is important to keep in mind that the projections shown in Table 5.5 assume no change in other factors relevant to the accession process; specifically, the number of recruiters and the pay relationships across regions are assumed to be constant through all projection years. Using CBO's January unemployment projections, Army male high school graduate enlistments in mental groups I-IIIA are projected to decline by nearly 21 percent over the period CY 1975-1986. In CY 1975, 15 percent of this group were non-white. Due to the fact that the non-white population is not expected to decline but actually increase slightly, and the fact that the forecasting model shows an inverse relationship between unemployment declines and enlistment results for non-whites, this proportion is expected to increase to 22 percent by CY 1986. These projections on aggregate enlistments and minority composition are summarized on Table 5.7.

Table 5.5

Projected I-IIIA DISC Accessions Under Projected Population and Unemployment Changes, by Race and Services
for October 1976 and January 1977 Unemployment Projections

October 1976 Projection										January 1977 Projection										
ARMY			NAVY			USAF			USMC			ARMY			NAVY			USAF		
White	Non-white	Total	White	Non-white	Total	White	Non-white	Total	White	Non-white	Total	White	Non-white	Total	White	Non-white	Total	White	Non-white	Total
1976	47021	8485	55506	48343	4314	52657	39214	4469	43683	19068	3287	22355								
1977	45580	8902	54382	48468	4564	50302	38265	4531	42796	19133	3326	22459								
1978	44202	9307	53509	48639	4809	53448	37333	4584	41917	19219	3360	22579								
1979	42777	9617	52394	48555	5000	53555	36505	4615	41120	19176	3380	22556								
1980	42420	9894	52314	48406	5169	53575	35753	4646	40399	19100	3399	22499								
1981	40489	10054	50543	48216	5266	53482	35282	4666	39948	19003	3412	22415								
1982	39280	10201	49481	47835	5357	53192	34740	4674	39414	18809	3417	22226								
1983	36434	10249	46668	46119	5393	51512	33896	4657	38653	17933	3407	21340								
1984	35408	10196	45604	45420	5370	50790	33633	4612	38245	17577	3378	20955								
1985	34319	10139	44458	44679	5345	50024	33355	4565	37920	17198	3348	20546								
1986	33355	10099	43654	44023	5328	49351	33108	4531	37639	16863	3126	20189								
1976	48160	8246	56406	48143	4161	52504	39911	4469	44380	19068	3287	22355								
1977	47207	8559	55766	48468	4346	52814	39261	4531	43792	19133	3326	22459								
1978	46480	8828	55308	48639	4504	53143	38727	4584	43311	19219	3360	22579								
1979	45705	9002	54707	48555	4607	53162	38297	4615	42912	19176	3380	22556								
1980	44186	9312	53498	48406	4798	53204	37446	4646	42092	19100	3399	22499								
1981	42767	9575	52342	48216	4960	53176	36677	4666	41343	19003	3412	22415								
1982	41069	9824	50893	47835	5008	52843	36333	4674	41007	18809	3417	22226								
1983	37573	10010	47583	46119	5240	51359	34593	4657	39350	17933	3407	21340								
1984	36547	9957	46504	45420	5217	50637	34330	4612	38942	17577	3378	20955								
1985	35458	9900	45358	44679	5192	49871	34052	4565	38617	17198	3348	20546								
1986	34494	9860	44354	44023	5175	49198	33805	4531	38336	16863	3326	20189								

Table 5.6
SUMMARY ENLISTMENT/QMA DATA

CY 1975

NPS Male Diploma Graduates

	White				Non-white				TOTAL
	1,2	3A	3B	4	1,2	3A	3B	4	
<u>Army</u>									
Accessions	31,043	16,806	15,779	3,838	2,899	5,247	11,675	4,804	92,091
Percent of total	34	18	17	4	3	6	13	5	100
<u>Navy</u>									
Accessions	30,334	17,797	11,176	2,921	1,742	2,376	2,744	1,031	70,121
Percent of total	43	25	16	4	3	3	4	2	100
<u>USMC</u>									
Accessions	11,504	7,456	5,847	595	1,416	1,818	2,265	310	31,211
Percent of total	37	24	19	2	5	6	7	1	100
<u>USAF</u>									
Accessions	24,528	15,303	9,863	463	1,704	2,681	2,728	95	57,365
Percent of total	42	27	17	1	3	5	5	<u>a/</u>	100
<u>DOD</u>									
Accessions	97,409	57,362	42,665	7,817	7,761	12,122	19,412	6,240	250,788
Percent of total	39	23	17	3	3	5	8	2	100
<u>QMA</u>	<u>b/</u>								
Population	1,322,366	486,084	462,233	304,823	19,871	22,689	56,417	99,967	2,774,450
Percent of total	48	18	17	11	1	1	2	4	100 <u>c/</u>

a/ Less than 0.5%.

b/ QMA includes all 17-21-year-old, diploma high school graduate non-prior service males who are qualified for military service.

c/ Percentages may not sum to 100 due to rounding.

Table 5.7

SUMMARY OF I-IIIa DISG ENLISTMENT
 PROJECTIONS USING THE JANUARY '77
 CBO UNEMPLOYMENT PROJECTIONS

	Army		Navy		Marine Corps		Air Force	
	Total	% Non-white	Total	% Non-white	Total	% Non-white	Total	% Non-white
1975 (actual)	55,995	14	52,249	8	22,194	14	44,216	10
1978	55,308	16	53,143	8	22,579	15	43,311	11
1982	50,893	19	52,843	10	22,226	15	41,007	11
1986	44,354	22	49,198	12	20,546	16	38,617	12
% 1975-86	-21%	--	-6%	--	-7%	--	-13%	--

Chapter 6

ACCESSION BUDGET IMPLICATIONS OF THE ENLISTMENT SUPPLY FORECASTS

GENERAL

The purpose of this chapter is to estimate what the potential cost would be to overcome the projected shortfalls displayed on Table 5.7 through increases in the services' accession budgets. The accession budgets include three components — recruiters, advertising media, and recruiter aides. The purpose of including a chapter in this study on the accession budget implications of the enlistment forecasts is to show what the potential cost would be if the present course of action is continued in the face of a smaller enlistable market. While no specific budget recommendations can be made solely on the basis of these results, the data should be of assistance to defense manpower policy analysts whose responsibility it is to choose the most cost-effective management options available to sustain an AVF.

METHODOLOGY

In order to estimate the budgetary implications of the enlistment shortfalls, an optimal budget allocation model has been employed. This model was developed under previous contract work for Department of the Army and Office Secretary of Defense.^{1/} Two fundamental assumptions are implicit in the modelling methodology. The first is that the programs employed diminish in effectiveness at an exponential rate and, at some point, provide no additional enlistments for each increment in the budget. The second assumption is that the various accession programs, such as recruiters, advertising media, and recruiter aides, are to some extent substitutes for one another. In the analysis in this chapter, the multiplicative exponential form^{1/} is assumed in the optimization. The algorithm allocates funds among the competing programs in a manner that will

^{1/} Documentation Report to Support the Analysis for Management of Recruiting Resources and Operations (AMRRO) System, General Research Corporation, CR-189, June 1977.

maximize the number of additional enlistments obtained from a specific dollar increment to the total accession budget.

The first step in using the model is to select a set of program elasticities and convert these into marginal products. These data are shown on Table 6.1 below.

Table 6.1
ACCESSION PROGRAM ELASTICITIES

	<u>Army</u>	<u>Navy</u>	<u>Marine Corps</u>	<u>Air Force</u>
Recruiters	.37	.57	.35	.68
Advertising media	.06	.06	.06	.06
Recruiter aides	.80	.80	.80	.80

These are the elasticities assumed to be in effect at CY 1975 enlistment supply levels. The only elasticities empirically derived from this study are the recruiter elasticities. These are the non-race-specific composite elasticities computed in Chapter 4 and displayed on Table 4.4. The advertising media elasticities were taken from a similar econometric study produced by GRC in 1974.^{2/} These measurements, while admittedly crude, are the best estimates available on the direct effect advertising has on enlistment supply. The recruiter aide elasticities were not empirically derived but they are based on the assumption that each person-year of recruiter aide support produces 12 additional quality enlistments. These assumptions were made by OSD(MRA&L) staff based on results experienced with the Army's recruiter canvasser program. While both the advertising media and recruiter aide programs are important, test simulations using the budget model developed by GRC show that the recruiter budget was the most essential component of the forecasts. The recruiter elasticities used here rest on a much more solid framework of analysis.

^{2/} Grissmer, D., et al., "An Econometric Analysis of Volunteer Enlistments by Service and Cost Comparison of Service Incentive Programs," OAD-CR-66, General Research Corporation, October 1974.

The elasticities shown on the previous table do not represent direct input into the model. Rather, they are used to compute marginal program productivities that are used as input to the model. In order to compute these program productivities, it is necessary to estimate the size of each component of the services' accession budgets. The budgets that were associated with CY 1975 enlistment supply levels are shown on the following table.

Table 6.2

SELECTED ACCESSION PROGRAM BUDGETS SUPPORTING CY 1975
ENLISTMENT SUPPLY LEVELS
(\$ millions)

	<u>Army</u>	<u>Navy</u>	<u>Marine Corps</u>	<u>Air Force</u>	<u>Total</u>
Recruiters	129.2	92.1	37.3	46.8	305.4
Advertising media	33.4	16.8	8.8	9.7	68.7
Recruiter aides	<u>2.1</u>	<u>2.1</u>	<u>2.1</u>	<u>.1</u>	<u>6.4</u>
Total	164.7	111.0	48.2	56.6	380.5

The data shown on this table exclude certain items that would normally be considered part of the accession budget. These are: enlistment bonuses, non-media advertising, the DOD marketing fund, lease of recruiting stations, AFEES operations, and leased housing for recruiters.

The purpose of this analysis is to determine what additions to the accession budget would be required to compensate for the lost enlistments due to population and unemployment declines. It would be useful to have an estimate of the proportion of the budgets that vary with enlistment workload. For purposes of this study, it is assumed that the advertising media and recruiter aides budgets shown on Table 6.2 are entirely variable. On the other hand, it is likely that there is some fixed component for the production recruiter budget that would not be expected to vary over a reasonable range of alternative enlistment levels and numbers of production recruiters. This analysis assumes that 65 percent of the recruiter budget, shown on Table 6.2, represents the variable component. This proportion is based on another study conducted by GRC in 1974.^{3/}

^{3/} Ibid.

In line with this reasoning, the following table shows the method used for computing marginal production rate for recruiters.

Table 6.3
MARGINAL PRODUCTION RATES FOR RECRUITERS

	<u>Army</u>	<u>Navy</u>	<u>Marine Corps</u>	<u>Air Force</u>
1. Recruiter budgets	\$129.2M	\$92.1M	\$37.3M	\$46.8M
2. Variable portion ((1)X.65)	\$ 83.9M	59.9M	24.2M	30.4M
3. CY'75 Recruiter MY	4,822	3,515	1,818	1,820
4. Variable cost per MY ((2)÷(3))	\$ 17,400	\$17,000	\$13,300	\$16,700
5. Recruiter elasticities	.37	.57	.35	.68
6. CY'75 Supply (I-IIIA HSG)	56,000	52,200	22,200	44,200
7. Marginal products ((5) X(6)÷(3))	4.3	8.5	4.3	16.5
8. Marginal cost ((4)÷(7))	\$ 4,046	\$ 2,000	\$ 3,100	\$ 1,012
9. Production per million \$ (\$1.0M ÷ (8))	247	500	322	988

The last line shows the number of additional quality enlistments that can be obtained for the next one million dollars invested in production recruiters for each Service at the base point, i.e., at CY 1975 accession levels and expenditures. These four values plus similar figures for recruiter aides and advertising media are input to the budget model and act as a starting basis to project accession budget costs at various enlistment levels.

RESULTS FROM THE BUDGET MODEL

Based on output from the optimal budget allocation model, Fig. 6.1 displays a series of accession budget production functions. The numbers annotated on each curve represent the marginal accession costs of recruiting the next additional quality enlistment at CY 1975 supply levels. In interpreting the figure, it is important to understand that each curve represents the relative responsiveness of the quality enlistable market

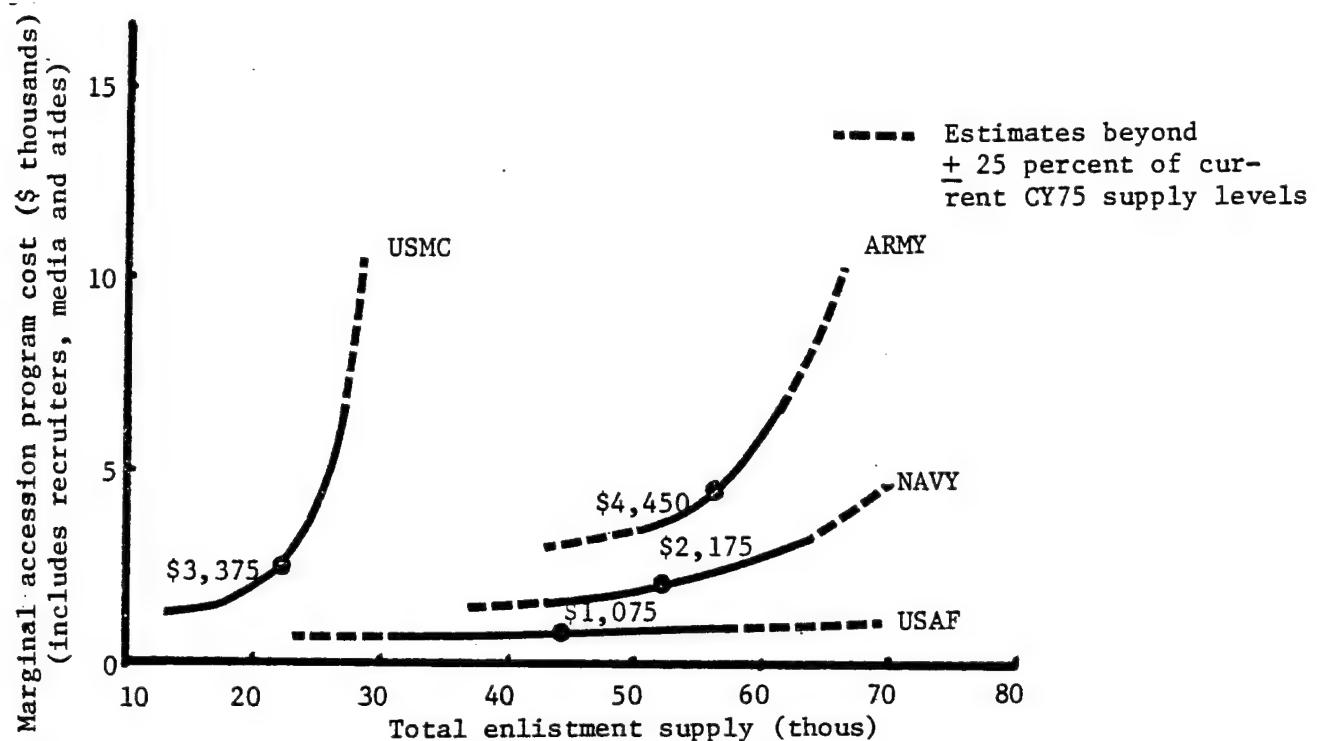


Fig. 6.1—Accession Production Functions
NPS Male, DHSG, I-IIIA (at CY 75
supply levels)

to changes in the accession resources under CY 1975 wage, unemployment and population conditions. Thus, if any one Service wishes to increase the number of enlistments it was obtaining from the enlistable market in CY 1975 and chose to do so by expanding its accession budget, it would operate along the curves displayed on Fig. 6.1. For example, if the Army decided it was necessary to increase the number of quality enlistments in CY 1975 from 56,000 to 67,000, for an increase of 20 percent, an approximate 50 percent increase in the accession budget would be required (i.e., from 165 million to 245 million). At that level, the cost of the next additional quality enlistment would be \$26,000. This example is intended to show that increasing the degree of market penetration experienced by each Service solely by additions to the accession budget can be very costly, and certainly other alternatives should be explored.

It is critical in interpreting the analysis discussed in this chapter to distinguish between a shift in a production function and a movement along a production function. The previous example showed the cost that would occur as the Army moves along its production function curve to increase its market penetration at CY 1975 enlistment supply levels.

The enlistment supply forecast described in Chapter 4 actually represents shifts in the supply curve each Service faces. Thus, changes in population and unemployment result in a shift of the production function as exemplified on Figure 6.2.

This figure shows schematically the magnitude and the shift in the production function that should occur when the supply of the enlistable market is reduced by declines in unemployment and population through projected CY 1986 level. The curve labelled I is essentially an expanded version of the CY 1975 Army production function curve. This is the production function the Army operated on when CY 1975 population and unemployment conditions were in effect. The slope of the curve at Point A (\$4,450 per accession) is the marginal cost of recruiting the next additional quality enlistment under CY 1975 resource levels.

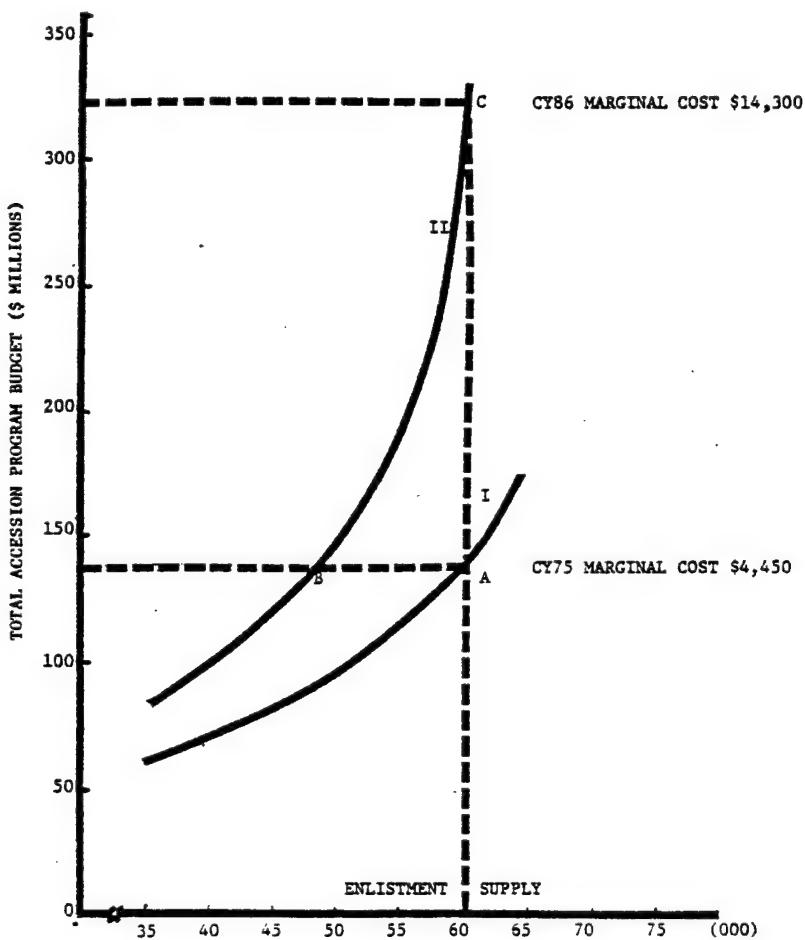


Fig. 6.2—Army Accession Production Functions
NPS Male, DHSG, I-IIIA

The curve labelled II is the anticipated production function the Army will face at CY 1986 enlistment supply levels. Assuming no change in the accession budget beyond that established in CY 1975, Point B shows that the Army can anticipate recruiting 21 percent fewer quality enlistments should it decide (or be forced) to maintain a status quo in its accession budget. Should the Army wish to restore the total number of enlistments lost to the population and unemployment decline, it will have to increase its accession budget along production function II up to Point C. At that point it will have achieved the same number of enlistments it realized in CY 1975, but the marginal cost of the next additional enlistment is approximately three times larger than it was under CY 1975 conditions. Attaining Point C requires a \$90 million or 56 percent increase in the annual accession budget over the 10-year period.

Hopefully, with some understanding of the budget implications of these shifts in the supply of quality enlistments, the results displayed on Table 6.4 should become more meaningful.

Table 6.4

CHANGE IN ACCESSION BUDGET TO OVERCOME
PROJECTED DECLINE IN NPS MALE DHSG I-III A
FROM CY 1975 LEVEL

<u>ARMY</u>				
	Shortfall from CY'75 Level	Accession Budget Required to Maintain CY 75 Levels	Average Cost Per Enlistment (CY'75 \$)	Marginal Cost per Enlistment (CY'75 \$)
	<u>(Millions CY'75 \$)</u>			
CY 1975 Actual	56,000	\$ 160.	\$ 2,860	\$ 4,450
CY 1978	(2,500)	175.	3,125	5,700
CY 1982	(6,500)	190.	3,400	6,900
CY 1986	(12,500)	250.	4,460	14,300

The data on the table show for three points in time beyond CY 1975 the anticipated quality enlistment shortfalls and the accession budget implications should the Army attempt to compensate for these shortages by increasing its budget to enlarge its market penetration. Each row on the table essentially represents a shift in the production function resulting from a reduced supply should population and unemployment decline as projected. Essentially, the table shows that by CY 1986 the Army would have to increase its accession budget by 60 percent to compensate for the 21 percent shrinkage in enlistment supply which will, in effect, triple the marginal cost of bringing in the next additional quality enlistment.

Accession budget results for the Navy are shown on the following table.

Table 6.5

CHANGE IN ACCESSION BUDGET TO OVERCOME
PROJECTED DECLINE IN NPS MALE DHSG I-IIIA
FROM CY 1975 LEVEL

<u>NAVY</u>				
	Shortfall from CY'75 Level	Accession Budget Required to Maintain CY'75 Levels (Millions CY'75 \$)	Average Cost Per Enlistment (CY'75 \$)	Marginal Cost per Enlistment (CY'75 \$)
CY 1975 Actual	52,249	\$ 111.0	\$ 2,125	\$ 2,175
CY 1978	+ 894	107.5	2,060	2,100
CY 1982	+ 594	108.0	2,070	2,100
CY 1986	(3,051)	115.0	2,200	2,350

Unlike the Army, the Navy faces a much less serious problem should it attempt to compensate for projected enlistment shortages through increases in its accession budget. Overall, the results show that if the Navy is required to maintain a status quo in the level of its accession budget, no significant decline in quality enlistments would occur. There are primarily two reasons for this. First, at the margin, the Navy is almost twice as

productive as the Army with respect to the recruitment of quality enlistments. Thus, each increment in the accession budget will produce for the Navy twice as many enlistments. Second, results from the econometric analysis conducted in Chapter 4 show that Navy quality enlistments are not sensitive to changes in unemployment rates and, therefore, the only decline in enlistments anticipated in this study is due to eventual declines in the population.

Like the Navy, the Marine Corps faces a very similar situation. The results in the study show that unemployment is not a factor in forecasting quality enlistments for the Marine Corps and, while its marginal productivity of recruiters approximates that of the Army, increases in the accession budget are required only to offset declines due to population. This is shown on Table 6.6.

Table 6.6

CHANGE IN ACCESSION BUDGET TO OVERCOME
PROJECTED DECLINE IN NPS MALE DHSG I-IIIA
FROM CY 1975 LEVEL

<u>MARINE CORPS</u>				
	Shortfall from CY'75 Level	Accession Budget Required to Maintain CY'75 levels (Millions CY'75 \$)	Average Cost Per Enlistment (CY'75 \$)	Marginal Cost per Enlistment (CY'75 \$)
CY 1975 Actual	22,200	\$ 48.0	\$ 2,160	\$ 3,375
CY 1978	+ 400	46.5	2,100	3,050
CY 1982	+ 0	48.0	2,160	3,375
CY 1986	(1,650)	53.0	2,390	4,100

For the Marine Corps, the results show that essentially a 10 percent increase in the accession budget would be sufficient to offset projected declines in enlistments experienced by CY 1986. While its accession budget need be increased by only 10 percent, its marginal cost will be 20 percent higher than CY 1975 levels and it does suggest that alternatives which may be more cost-effective should be evaluated to compensate for the lost enlistments anticipated by 1986.

The Air Force is anticipated to experience declines in quality enlistments due to both population and unemployment shifts by CY 1986. In spite of the fact that the Air Force is projected to experience a 13 percent decline in enlistments, only minimal increases in its accession budget will be required to compensate for this shift in quality enlistment supply. The results of this analysis are shown on Table 6.7.

Table 6.7

CHANGE IN ACCESSION BUDGET TO OVERCOME
PROJECTED DECLINE IN NPS MALE DHSG I-III
FROM CY 1975 LEVEL

AIR FORCE

	Shortfall from CY'75 Level	Accession Budget Required to Maintain CY'75 Levels (Millions CY'75 \$)	Average Cost Per Enlistment (CY'75 \$)	Marginal Cost per Enlistment (CY'75 \$)
CY 1975 Actual	44,200	\$ 54.0	\$ 1,220	\$ 1,075
CY 1978	(900)	55.0	1,240	1,100
CY 1982	(3,200)	56.5	1,280	1,150
CY 1986	(5,600)	58.0	1,310	1,175

At the margin, Air Force recruiters are approximately four times more productive than Army recruiters for the same quality group. As a consequence, an increase in their accession budget of about 7 percent would be sufficient to sustain CY 1975 quality enlistment levels for the Air Force. At that level, only minimal increases in marginal costs will occur.

In summary, it is evident from the analyses that only the Army faces a severe budget problem if it attempts to compensate for the shifts in enlistment supply through additions to its accession budget. Serious examination of more cost-effective management options which results in a broadening of the enlistable market in contrast to the costly approach of increasing penetration of the currently defined enlistable market, i.e., male, DHSG, I-III applicants, is essential at the present time.

APPENDIX A

LINEARIZATION TRANSFORMATIONS FOR LEAST SQUARES PROBLEMS

LINEARIZATION TRANSFORMATIONS FOR LEAST SQUARES PROBLEMS

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In various elementary courses of mathematics and statistics, the student is introduced to least squares curve fitting. After learning to obtain linear least squares fits, he is almost invariably presented with the form $y = ae^{bx}$ and told that by application of the transformation $z = \ln y$ he can reduce the least squares problem associated with this exponential form to a linear least squares problem. What he is seldom told, however, is that the application of the logarithmic transformation distorts his scale so that minimization of $\sum(\ln y_i - (\ln a + bx_i))^2$ is not equivalent to minimization of $\sum(y_i - ae^{bx_i})^2$. This observation is not new, see [1], p. 195, for example, but it has been neglected to the extent that the

student is seldom given a valid method for application of linearization transformations. Some authors (see [4], p. 709, and, [5], pp. 186-191, for example) point out the errors that can result from nonrigorous linearization, but then, rather than proposing a valid method for linearization, they suggest the iterative method of differential corrections as an alternative to be preferred. Many others choose to propose nonrigorous linearization exercises with no word of caution for the student. The few authors who do point the way to a valid linearization method generally seem to base their discussions on the idea of statistical weighting, and they do not appear to attempt a rigorous mathematical justification of the method or a computation of error bounds (for example, see [1], p. 194; [2], p. 302; [3], p. 536). All of this is unfortunate, since many least squares problems arising in data analysis are associated with simple nonlinear forms which are susceptible to linearization transformations. A few such forms and the associated transformations are listed below.

Form	Linearization Transformation
$y = ae^{bx}$	$z = \ln y$
$y = ax^b$	$z = \ln y$
$y = \ln(a + bx)$	$z = e^y$
$y = \{a^2 + b^2 x^2\}^{1/2}$	$z = y^2$
$y = a(x - b)^2$	$z = \sqrt{y}$
$y = a/(b - x)$	$z = 1/y$
$y = ax/(b - x)$	$z = 1/y$

For forms such as these, the use of linearization transformations is both computationally more efficient and aesthetically more satisfying than the use of iterative techniques, such as the method of differential corrections and the Newton-Raphson method, to solve the nonlinear normal equations. Of course, the accuracy obtainable with linearization transformations is not as good as that obtainable with the iterative techniques; but, even when very high accuracy is required, linearization transformations are of value in providing good initial estimates for the iterative techniques. The purpose of this note, then, is to establish, for the undergraduate, a theoretical framework within which the proper application of linearization transformations can be justified.

For conciseness, we will consider forms $y = f(x, a, b)$ which involve only two parameters to be determined by least squares. The results are perfectly general, however, and their extension to any number of parameters is obvious. Suppose, then, that we are given the form $y = f(x, a, b)$ and a set of data points $\{(x_i, y_i)\}_{i=1}^n$, $n > 2$. We consider the least squares problem of minimizing the function

$$S(a, b) = \sum_{i=1}^n \{y_i - f(x_i, a, b)\}^2.$$

It is assumed that there is a set $X \subset R_1$, with $x_i \in X$ ($i = 1, \dots, n$), and an open set $D \subset R_2$, such that f is a function from $X \times D$ to R_1 and S is a function from D to R_1 (where R_k denotes the set of all k -tuples of real numbers, with the Euclidean metric topology). For each i ($i = 1, \dots, n$), the partial derivatives of $f(x_i, a, b)$ with respect to a and b are assumed to exist at all points of D . Let Y

be a connected subset of R_1 which contains the range of f and the numbers y_1, \dots, y_n from the data. A function $g: Y \rightarrow R_1$ is said to be a *linearization transformation* for the form $y = f(x, a, b)$ provided there exist functions P, Q, R , from X to R_1 , and functions A, B , from D to R_1 , such that for all $x \in X$ and all $(a, b) \in D$

$$g[f(x, a, b)] = A(a, b)P(x) + B(a, b)Q(x) + R(x)$$

and such that the Jacobian $\partial(A, B)/\partial(a, b)$ is nonvanishing in D . For example, consider the form $y = a(x-b)^2$, and let $m = \text{smallest } x_i$ in the set of data. Let $X = \{x: x \geq m\}$ and let $D = \{a: a > 0\} \times \{b: b < m\}$. Let $f(x, a, b) = a(x-b)^2$ for all $x \in X$ and all $(a, b) \in D$. Suppose all the y_i 's are positive, and let $Y = \{y: y > 0\}$. Then $g(y) = y^{1/2}$ is a linearization transformation for the form $y = f(x, a, b) = a(x-b)^2$, since $g[a(x-b)^2] = Ax + B$ where $A = A(a, b) = \sqrt{a}$ and $B = B(a, b) = -b\sqrt{a}$ for all (a, b) in D , and $\partial(A, B)/\partial(a, b) = -1/2$. Here, of course, P leaves all points of X fixed, Q maps all points of X to 1, and R maps all points of X to 0.

We return now to the general case. If g is a linearization transformation for the form $y = f(x, a, b)$ then, for any given set of numbers w_1, \dots, w_n , one can consider the least squares problem of determining a and b so that the function

$$\begin{aligned} T(a, b; w_1, \dots, w_n) &= \sum_{i=1}^n w_i \{g[y_i] - g[f(x_i, a, b)]\}^2 \\ &= \sum_{i=1}^n w_i \{g[y_i] - [A(a, b)P(x_i) + B(a, b)Q(x_i) + R(x_i)]\}^2 \\ &= H(A, B; w_1, \dots, w_n) \end{aligned}$$

will be minimized. For each set of numbers w_1, \dots, w_n , this associated least squares problem is a *weighted linear least squares problem* in terms of the parameters A and B , so that the normal equations $\partial H/\partial A = \partial H/\partial B = 0$ are linear and can be solved for A and B by the usual methods for linear systems. One can then obtain a and b by simultaneous solution of the equations $A(a, b) = A$, $B(a, b) = B$, since $\partial(A, B)/\partial(a, b) \neq 0$.

THEOREM. Suppose $S(a, b)$ is minimized at the point (a_0, b_0) in D . If the linearization transformation g has a nonzero derivative at each point of Y , then there exist numbers w_1, \dots, w_n such that $T(a, b; w_1, \dots, w_n)$ is minimized at (a_0, b_0) .

Proof. We have $\partial S/\partial a = \partial S/\partial b = 0$ at (a_0, b_0) , whence

$$\sum_{i=1}^n (y_i - f(x_i, a_0, b_0))f_a(x_i, a_0, b_0) = 0$$

$$\sum_{i=1}^n (y_i - f(x_i, a_0, b_0))f_b(x_i, a_0, b_0) = 0.$$

For any numbers w_1, \dots, w_n we have

$$T_a(a_0, b_0; w_1, \dots, w_n)$$

$$= -2 \sum_{i=1}^n w_i \{g[y_i] - g[f(x_i, a_0, b_0)]\} g'[f(x_i, a_0, b_0)] \cdot f_a(x_i, a_0, b_0).$$

By the mean value theorem, for each i ($i=1, \dots, n$) there exists a point ξ_i between y_i and $f(x_i, a_0, b_0)$ such that

$$g[y_i] - g[f(x_i, a_0, b_0)] = g'(\xi_i) \{y_i - f(x_i, a_0, b_0)\}$$

and so we see that we will have $T_a(a_0, b_0; w_1, \dots, w_n) = 0$ provided we set $w_i = 1/\{g'(\xi_i)g'[f(x_i, a_0, b_0)]\}$, $i=1, \dots, n$. It is clear that this same set of w_i 's will make $T_b(c_0, b_0; w_1, \dots, w_n) = 0$. Now since

$$\frac{\partial T}{\partial a} = \frac{\partial H}{\partial A} \cdot \frac{\partial A}{\partial a} + \frac{\partial H}{\partial B} \cdot \frac{\partial B}{\partial a}, \quad \frac{\partial T}{\partial b} = \frac{\partial H}{\partial A} \cdot \frac{\partial A}{\partial b} + \frac{\partial H}{\partial B} \cdot \frac{\partial B}{\partial b},$$

and since the Jacobian $\partial(A, B)/\partial(a, b) \neq 0$ at (a_0, b_0) , we see that $\partial H/\partial A = \partial H/\partial B = 0$ at $A_0 = A(a_0, b_0)$, $B_0 = B(a_0, b_0)$. But it is well known that the linear normal equations $\partial H/\partial A = \partial H/\partial B = 0$ have a unique solution and that this solution does indeed correspond to the minimum of the function $H(A, B; w_1, \dots, w_n) = T(a, b; w_1, \dots, w_n)$.

From a practical standpoint, one might, of course, use estimates of these weights $w_i = 1/\{g'(\xi_i)g'[f(x_i, a_0, b_0)]\}$ in the linearization procedure. Since it is expected that a_0 and b_0 will turn out such that $f(x_i, a_0, b_0)$ will be fairly close to y_i , for $i=1, \dots, n$, and since ξ_i must be between $f(x_i, a_0, b_0)$ and y_i , it is reasonable to use $w_i^* = 1/\{g'(y_i)\}^2$ as an estimate of w_i provided g' is continuous. One can then solve the weighted linear least squares problem, using the weights w_i^* , to obtain A_0^*, B_0^* ; and a_0^*, b_0^* are then obtained by simultaneous solution of the equations $A(a_0^*, b_0^*) = A_0^*$, $B(a_0^*, b_0^*) = B_0^*$. The remaining problem is to estimate upper bounds for $|\Delta a_0^*| = |a_0^* - a_0|$ and $|\Delta b_0^*| = |b_0^* - b_0|$. We have

$$\Delta w_i^* = w_i^* - w_i = \frac{1}{\{g'(y_i)\}^2} - \frac{1}{g'(\xi_i)g'[f(x_i, a_0, b_0)]}.$$

Assuming g' to be monotonic, (which will generally be the case in applications) we have

$$|\Delta w_i^*| \leq \left| \frac{1}{\{g'(y_i)\}^2} - \frac{1}{\{g'(f(x_i, a_0, b_0))\}^2} \right|.$$

If we assume the existence of g'' at all points of Y (again a plausible assumption), then the mean value theorem gives us the existence of points η_i between y_i and $f(x_i, a_0, b_0)$ such that

$$|\Delta w_i^*| \leq \left| \frac{-2g''(\eta_i)}{\{g'(\eta_i)\}^3} \{y_i - f(x_i, a_0, b_0)\} \right|.$$

Finally, assuming $|2g''/(g')^3| \leq M$ on Y (or, at least, on a connected subset of Y containing the points y_i and $f(x_i, a_0, b_0)$, $i = 1, \dots, n$), we have

$$|\Delta w_i^*| \leq M \cdot |y_i - f(x_i, a_0, b_0)|$$

and so

$$\sum_{i=1}^n (\Delta w_i^*)^2 \leq M^2 \sum_{i=1}^n \{y_i - f(x_i, a_0, b_0)\}^2 \leq M^2 \sum_{i=1}^n \{y_i - f(x_i, a_0^*, b_0^*)\}^2$$

since $S(a, b)$ is minimized at (a_0, b_0) .

Differentiating the normal equations $\partial H/\partial A = \partial H/\partial B = 0$ partially with respect to w_i^* yields equations which are linear in $\partial A_0^*/\partial w_i^*$ and $\partial B_0^*/\partial w_i^*$. Hence, we get

$$\frac{\partial A_0^*}{\partial w_i^*} = k_i \{g[y_i] - g[f(x_i, a_0^*, b_0^*)]\} \quad \text{and} \quad \frac{\partial B_0^*}{\partial w_i^*} = l_i \{g[y_i] - g[f(x_i, a_0^*, b_0^*)]\},$$

where

$$k_i = \frac{P(x_i) \sum_{j=1}^n w_j^* Q(x_j)^2 - Q(x_i) \sum_{j=1}^n w_j^* P(x_j) Q(x_j)}{\left(\sum_{j=1}^n w_j^* P(x_j)^2 \right) \left(\sum_{j=1}^n w_j^* Q(x_j)^2 \right) - \left(\sum_{j=1}^n w_j^* P(x_j) Q(x_j) \right)^2}$$

and

$$l_i = \frac{Q(x_i) \sum_{j=1}^n w_j^* P(x_j)^2 - P(x_i) \sum_{j=1}^n w_j^* P(x_j) Q(x_j)}{\left(\sum_{j=1}^n w_j^* P(x_j)^2 \right) \left(\sum_{j=1}^n w_j^* Q(x_j)^2 \right) - \left(\sum_{j=1}^n w_j^* P(x_j) Q(x_j) \right)^2}.$$

Finally, we have

$$\Delta A_0^* \approx \sum_{i=1}^n \frac{\partial A_0^*}{\partial w_i^*} \Delta w_i^*$$

so that, using the Cauchy-Schwarz inequality

$$(\Delta A_0^*)^2 \leq \left\{ \sum_{i=1}^n \left(\frac{\partial A_0^*}{\partial w_i^*} \right)^2 \right\} \cdot \left\{ \sum_{i=1}^n (\Delta w_i^*)^2 \right\},$$

whence

$$(\Delta A_0^*)^2 \leq \left(\sum_{i=1}^n k_i^2 \{g[y_i] - g[f(x_i, a_0^*, b_0^*)]\}^2 \right) \left(M^2 \sum_{i=1}^n \{y_i - f(x_i, a_0^*, b_0^*)\}^2 \right).$$

Similarly, we obtain

$$(\Delta B_0^*)^2 \leq \left(\sum_{i=1}^n \{s[y_i] - s[f(x_i, a_0^*, b_0^*)]\}^2 \right) \left(M^2 \sum_{i=1}^n \{y_i - f(x_i, a_0^*, b_0^*)\}^2 \right).$$

Bounds for Δa_0^* and Δb_0^* can now be obtained by examining the transformations $A(a, b)$, $B(a, b)$ to see what region of the ab -plane corresponds to the region $A_0^* \pm |\Delta A_0^*|_{\max}$, $B_0^* \pm |\Delta B_0^*|_{\max}$ of the AB -plane.

As a numerical example, consider fitting the three data points $(x_i, y_i) = (3, 0.2), (4, 2.3), (5, 4.4)$, with the form $f(x, a, b) = a(x-b)^2$ discussed above. One may easily check that an exact solution of the normal equations is $a_0 = .500$, $b_0 = 2.00$, and that this solution does indeed minimize $S(a, b)$. Linearization is accomplished by the transformation $g[y] = y^{1/2}$, and we have $A = \sqrt{a}$, $B = -b\sqrt{a}$, $P(x) = x$, $Q(x) = 1$, $R(x) = 0$. Using the weights $w_i^* = 1/\{g'[y_i]\}^2 = 4y_i$, we obtain $A_0^* = .6579$ and $B_0^* = -1.176$, whence $a_0^* = (A_0^*)^2 = .433$ and $b_0^* = -B_0^*/A_0^* = 1.79$. Noting that $-2g''/(g')^3 = 4$, we compute error bounds as indicated above: $|\Delta A_0^*| \leq .1317$, $|\Delta B_0^*| \leq 0.631$. Hence A_0 should be in the interval [.5262, .7896], and B_0 should be in the interval [-1.807, -0.545]. The actual values of A_0 , B_0 are, of course, $A_0 = .7071$ and $B_0 = -1.414$. The inverse transformation equations $a = A^2$, $b = -B/A$ now give us at once the following bounds for a_0 and b_0 : $.277 \leq a_0 \leq .623$, $0.69 \leq b_0 \leq 3.43$. It is interesting to observe that the usual non-rigorous linearization (accomplished with the same transformation but with all weights set equal to 1) yields $A_0^{**} = .8252$, $B_0^{**} = -1.947$, whence $a_0^{**} = (A_0^{**})^2 = .681$ and $b_0^{**} = -B_0^{**}/A_0^{**} = 2.36$. We note that $|a_0^{**} - a_0| > |a_0^* - a_0|$ and $|b_0^{**} - b_0| > |b_0^* - b_0|$, and that the error bounds obtained above for a_0 actually exclude the value $a_0^{**} = .681$. Finally, we have $S(a_0, b_0) = .190$, $S(a_0^*, b_0^*) = .226$, and $S(a_0^{**}, b_0^{**}) = .345$.

It is to be noted that our error bounds for A_0^* and B_0^* are, in fact, bounds for the total differentials of A_0^* and B_0^* with respect to the w_i^* , $i = 1, \dots, n$. These bounds are therefore approximate. We recall, however, that $|\Delta w_i^*| \leq M \cdot |y_i - f(x_i, a_0, b_0)|$ so that if a good fit of the data is possible with the form $y = f(x, a, b)$ and if $|2g''/(g')^3|$ is not too large, then the Δw_i^* will be small and our error bounds should be valid. In practice, an indication of the validity of the bounds can be obtained by observing the size of $M^2 \sum_{i=1}^n \{y_i - f(x_i, a_0^*, b_0^*)\}^2$ which is an upper bound for $\sum_{i=1}^n (\Delta w_i^*)^2$.

References

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APPENDIX B

SOURCE DATA

Table B-1

GRG VOLUNTEER DATA BASE EXTRACT
DATA COVERS JAN-DEC 76
SERVICE = ARMY
SERVICE CODE = 1
(NPS MALE ACCESSIONS , H.S. GRADE)

WHITE

BLACK + OTHER

SEN. NO.	STATE	CAT 1,2	CAT 3A	CAT 3B	CAT 4	CAT 1,2	CAT 3A	CAT 3B	CAT 4	TOTAL
1	ALABAMA	401	279	181	11	233	461	592	93	2,250
2	ALASKA	36	20	9	6	2	1	3	4	76
4	ARIZONA	511	243	233	51	16	21	66	16	1,159
5	ARKANSAS	230	160	148	39	46	94	264	132	1,103
6	CALIFORNIA	2,796	1,768	1,914	677	225	363	836	496	9,110
8	COLORADO	453	263	219	58	16	20	45	16	1,020
9	CONNECTICUT	432	190	156	50	18	29	76	54	1,007
10	DELAWARE	80	43	44	16	10	14	58	36	307
11	WASHINGTON DC	8	3	4	2	27	44	113	50	259
12	FLORIDA	1,716	906	713	59	105	271	752	193	4,717
13	GEORGIA	706	419	394	37	163	304	802	105	3,090
15	HAWAII	17	24	29	9	69	81	199	104	559
16	IDAHO	206	84	71	19	1	2	4	2	391
17	ILLINOIS	1,303	650	594	174	97	192	507	274	3,791
18	INDIANA	1,019	534	484	125	53	55	141	91	2,502
19	IOWA	579	246	202	63	5	6	16	7	1,124
20	KANSAS	341	133	143	29	9	18	37	22	736
21	KENTUCKY	353	281	360	66	24	54	139	52	1,330
22	LOUISIANA	141	97	90	10	91	109	513	260	1,391
23	MAINE	255	171	161	30	1	0	1	0	619
24	MARYLAND	441	271	250	59	58	114	312	186	1,693
25	MASSACHUSETTS	917	465	395	81	18	32	61	39	2,006
26	MICHIGAN	1,321	773	814	223	71	132	322	154	3,810
27	MINNESOTA	928	453	333	88	6	6	13	1	1,834
28	MISSISSIPPI	142	89	85	22	73	153	403	261	1,227
29	MISSOURI	733	385	370	79	12	53	125	87	1,870
30	MONTANA	231	95	59	21	5	4	6	3	426
31	NEBRASKA	231	129	110	33	9	4	15	14	609
32	NEVADA	102	44	37	11	4	7	15	12	232
33	NEW HAMPSHIRE	274	119	99	16	0	0	0	0	512
34	NEW JERSEY	840	396	353	75	116	174	346	127	2,417
35	NEW MEXICO	179	123	206	41	7	11	35	20	628
36	NEW YORK	2,109	1,093	1,029	226	191	299	662	244	5,850
37	NORTH CAROLINA	735	538	362	43	226	406	905	142	3,459
38	NORTH DAKOTA	120	64	58	13	4	4	5	5	273
39	OHIO	1,783	1,053	1,061	256	13	156	372	205	4,969
40	OKLAHOMA	445	217	233	79	27	42	136	85	1,264
41	OREGON	573	252	219	65	5	7	15	3	1,139
42	PENNSYLVANIA	1,692	692	797	200	96	214	421	217	4,727
44	RHODE ISLAND	1,371	74	36	19	6	6	13	5	328
45	SOUTH CAROLINA	237	160	155	4	113	255	560	86	1,560
46	SOUTH DAKOTA	134	86	20	17	6	5	11	4	393
47	TENNESSEE	491	323	316	62	47	136	351	202	1,932
48	TEXAS	1,307	773	900	279	170	293	640	384	6,746
49	UTAH	222	104	91	31	2	1	8	4	463
50	VERMONT	132	64	60	16	0	0	0	0	280
51	VIRGINIA	645	283	237	32	275	356	572	144	2,544
51	WASHINGTON	816	359	299	93	19	17	26	26	1,653
54	WEST VIRGINIA	189	165	220	49	10	11	36	14	697
55	WISCONSIN	926	404	321	26	14	23	35	30	1,835
56	WYOMING	44	26	19	4	1	1	2	1	98
	TOTALS	31,043	16,805	15,779	3,036	2,899	5,267	11,675	4,888	92,091

Table B-3

三才圖會

GRG VO-UNTEER DATA BASE EXTRAC

SERVICE COE 4

PS YALE ACCESSIONS ! H. S. G.

THE
TITLES

BLACK HELL

Table D-4

GR-3 VOLUNTEER DATA BASE EXTRACT SERVICE = MARINES
DATA COVERS JAN-JEC 76

NINPS VALE ACCESSIONS , H.S. GRADS!

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SEN. NJ.	STATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	8010	8011	8012	8013	8014	8015	8016	8017	8018	8019	8020	8021	8022	8023	8024	8025	8026	8027	8028	8029	8030	8031	8032	8033	8034	8035	8036	8037	8038	8039	8040	8041	8042	8043	8044	8045	8046	8047	8048	8049	8050	8051	8052	8053	8054	8055	8056	8057	8058	8059	8060	8061	8062	8063	8064	8065	8066	8067	8068	8069	8070	8071	8072	8073	8074	8075	8076	8077	8078	8079	8080	8081	8082	8083	8084	8085	8086	8087	8088	8089	8090	8091	8092	8093	8094	8095	8096	8097	8098	8099	80100	80101	80102	80103	80104	80105	80106	80107	80108	80109	80110	80111	80112	80113	80114	80115	80116	80117	80118	80119	80120	80121	80122	80123	80124	80125	80126	80127	80128	80129	80130	80131	80132	80133	80134	80135	80136	80137	80138	80139	80140	80141	80142	80143	80144	80145	80146	80147	80148	80149	80150	80151	80152	80153	80154	80155	80156	80157	80158	80159	80160	80161	80162	80163	80164	80165	80166	80167	80168	80169	80170	80171	80172	80173	80174	80175	80176	80177	80178	80179	80180	80181	80182	80183	80184	80185	80186	80187	80188	80189	80190	80191	80192	80193	80194	80195	80196	80197	80198	80199	80200	80201	80202	80203	80204	80205	80206	80207	80208	80209	80210	80211	80212	80213	80214	80215	80216	80217	80218	80219	80220	80221	80222

Table R-5

TOTAL HIGH SCHOOL GRADUATE DATA POPULATION AS OF JUNE 1977

WHITES BY RENTAL CATEGORY

NON-WHITES BY RENTAL CATEGORY

STATE	WHITES BY RENTAL CATEGORY			NON-WHITES BY RENTAL CATEGORY		
	1	11	111A	1-111A	111B	1-111
AL	970	8275	5550	14003	6016	20819
AK	16	59	25	100	20	120
AR	1844	8756	4363	14963	3403	18366
AZ	969	5916	3369	10254	3563	13817
AR	16981	85580	42226	144617	36848	101665
CA	2711	13942	5747	22400	4423	26623
CO	2863	14456	6943	24262	6962	31224
CT	545	2777	1476	4798	1591	6369
DE	20	99	52	171	43	214
DC	3610	26574	14730	44914	16384	61298
FL	1771	13287	8470	23528	8566	32094
GA	103	537	216	856	249	1105
HI	1262	5197	2390	8049	2256	11105
ID	9613	56956	26712	95481	27354	122835
IL	5567	30796	14703	51066	13038	64104
IN	5252	25391	10347	40990	7539	48529
IA	3274	16127	6798	26199	5257	31456
KS	1456	9704	6024	17184	6489	23673
KY	844	7276	4550	12670	5470	16140
LA	1093	5147	3112	9352	3052	12404
ME	2766	14612	7495	24893	7781	32674
MD	4608	27590	15463	47661	14653	62514
MA	7322	48934	25812	62068	26921	108989
MI	7258	32401	14045	53704	12991	66695
MS	643	4915	2915	8473	3492	11965
MO	3664	21751	11134	36549	12087	49436
MT	1370	5559	2245	9174	1020	10994
NB	2513	13005	5723	21241	4881	26122
NV	402	2294	1021	3717	808	4525
NH	816	3028	1963	6547	1645	8192
NJ	4036	27167	12175	46378	13885	60263
NI	929	6409	2361	7679	2459	10138
NY	11087	62447	34243	107777	32580	140357
NC	1784	13695	8601	24280	8989	33269
ND	865	4463	1688	7216	1591	8807
OH	10910	57290	27610	95810	23810	119620
OK	2015	10892	5306	18273	4685	22958
OK	3501	16509	7576	27586	5840	33426
PA	10094	61560	32432	104086	32173	136259
RI	574	4182	2518	7274	2154	9428
SD	556	4972	3223	8751	3265	12016
SC	948	4762	2174	7904	1461	9365
SD	1749	11670	7716	21135	8496	24631
TX	6591	37924	19896	64411	20329	84740
UT	2007	8032	3110	13157	3220	16377
VI	603	3178	1419	5280	1326	6606
VA	2397	15456	6504	26357	10257	36614
VA	5025	20163	8744	33932	6451	40383
WA	1033	6319	3948	13350	4630	15980
WV	6899	34530	16358	57767	13467	71234
WV	646	2636	1138	4620	977	5597

HIGH SCHOOL GRADUATE QPA POPULATION IN SCHOOL AS OF JUNE, 1977

WHITES BY RENTAL CATEGORY

NON-WHITES BY RENTAL CATEGORY

STATE	WHITES BY RENTAL CATEGORY			NON-WHITES BY RENTAL CATEGORY		
	1	II	III	1-111A	1-111B	1-111
AL	519	4415	2965	7899	3202	11101
AK	6	21	9	36	7	43
AZ	1103	5233	2607	8943	2034	10977
AR	526	3202	1816	5544	1914	7458
CA	9975	50292	24811	85078	21635	106713
CO	1565	8368	3327	12960	2552	15512
CT	1808	9127	4383	15318	4396	19714
DE	298	1516	667	2621	870	3491
DC	17	84	44	145	37	182
FL	2104	15481	8576	26161	9542	35703
GA	1095	8192	5223	14510	5280	19790
HI	52	270	169	431	126	557
IL	755	3103	1423	5261	1315	6616
IN	2618	33725	16989	26532	16239	72771
IA	3220	17763	8456	29439	7474	36913
KS	3140	15157	6162	24459	4470	28929
LA	2132	10502	4419	17053	3402	20455
KY	714	6793	3003	6510	3243	11753
LA	449	3867	2419	6735	2906	9641
MD	708	3340	2020	6068	1983	8051
MA	1555	8131	4165	13851	4318	18169
MA	2905	17370	9732	30007	9366	39373
MI	4101	27295	14359	45755	14992	60747
MI	16229	7900	30202	7290	37492	6
MS	397	3036	1799	5232	2157	7389
MO	2169	12926	6411	21046	7425	28471
MT	871	3530	1627	5828	1159	6987
NB	1500	7785	3432	12717	2932	15652
NV	207	1170	519	1096	415	2311
NH	485	2284	1133	3902	990	4892
NJ	2395	16102	8994	27491	8229	35720
NM	539	2566	1365	4470	1436	5906
NY	7022	39109	21281	67412	20135	87547
NC	1031	8020	4967	14016	5191	19209
ND	200	2669	1257	4806	1067	5873
OH	5906	31001	14939	51866	12680	64726
OK	1266	6828	3363	11457	2932	14389
PA	5662	34685	18325	58672	10251	76923
RI	379	2776	1674	4829	1430	6259
SC	346	3117	2026	5489	2051	7540
SD	574	2691	1316	4781	886	5667
TH	989	6561	4353	11923	4792	16715
VA	2062	9743	4473	16278	3448	19726
WA	2970	11899	5156	20025	3808	23833
WV	569	3472	12207	39586	12477	52063
WI	3760	18611	8896	31467	7334	38801
WY	384	1693	678	2755	582	3337

HIGH SCHOOL GRADUATE AND POPULATION NOT IN SCHOOL AS OF JUNE, 1977

NON-HUMANITIES OR DENIAL CATEGORY

MUN. MACHINES OF RENTAL CATALOGUE										
STATE	1	II	III	III A	III B	III C	III D	III E	III F	III G
AL	451	3060	2593	6904	2014	9718		1	116	262
AK	10	38	16	64	13	77		0	119	60
AZ	741	3523	1756	6020	1369	7389		27	168	164
AR	443	2714	1553	4710	1649	6329		1	68	150
CA	7006	35288	17445	59739	15213	74952		174	1726	1758
CO	1146	5074	2420	9440	1671	11311		3	68	81
CT	1055	5329	2560	8944	2566	11510		5	76	110
DE	247	1261	669	2177	721	2098		0	55	67
DC	3	15	8	26	6	32		8	139	279
FL	1506	11093	6154	16753	6842	22595		7	249	526
GA	676	5095	3247	9018	3286	12304		0	222	463
HI	51	267	107	425	123	548		198	1040	563
ID	367	2094	967	3568	921	4489		3	16	10
IL	3995	23231	11723	38949	11115	50064		39	709	1157
IN	2347	13033	6247	21627	5564	27191		3	191	315
IA	2112	10234	4185	16531	3069	19600		1	31	35
KS	1142	5625	2379	9146	1855	11001		11	8C	62
KY	742	4911	3021	8674	3246	11920		0	42	64
LA	395	3409	2131	5935	2566	8499		5	116	215
MD	365	1607	1052	3284	1069	4353		0	0	0
MI	1231	6481	3330	11042	3463	14505		10	324	551
MA	1703	10220	5731	17654	5487	23141		7	147	157
MI	3221	21639	11453	36313	11929	48242		13	411	777
NH	3185	14172	6145	23502	5701	29203		9	78	72
NS	246	1679	1116	3241	1335	4576		0	49	131
NO	1555	9225	4723	15503	5462	20965		11	266	476
NJ	499	2029	818	3346	661	4007		0	14	18
NB	1013	5220	2291	6524	1946	10470		6	41	41
NV	195	1124	502	1821	393	2214		7	11	24
NH	331	1544	770	2645	655	3300		0	1	1
NI	1641	11065	6181	16887	5656	24543		12	506	719
NH	390	1843	976	3209	1023	4232		4	50	42
NY	4065	23338	12962	40365	12445	52810		71	975	1702
NC	753	5675	3634	10262	3798	14660		5	296	552
ND	285	1494	631	2410	524	2934		0	24	27
OH	5004	26289	12671	43964	10930	54894		22	622	999
OK	749	4064	2003	6816	1753	8569		10	165	182
OR	1439	6766	3103	11308	2392	13700		20	139	115
PA	4432	26875	14107	45414	13922	59336		17	725	1220
KI	195	1406	844	2445	724	3169		0	19	4
SC	210	1655	1197	3262	1214	4676		0	63	174
SD	374	1891	853	3123	575	3698		0	30	46
TN	760	5009	3363	9212	3704	12916		2	254	314
TX	2527	14609	7689	24825	7852	32677		15	332	543
VI	769	3100	1206	3075	1239	6314		0	16	15
VI	220	1018	455	1693	425	2118		1	1	2
VA	955	6152	3378	10485	4068	14553		4	212	350
WA	2055	8264	3588	13907	2643	16550		14	96	187
WA	404	2847	1797	5108	2077	7165		1	31	38
WV	3139	15719	7442	26300	6133	32433		2	97	108
WY	262	1143	460	1862	395	2260		4	2	270

Table B -8

Recruiters on Station 31 October 1977

Source: USAREC

<u>State</u>	<u>Army</u>	<u>Navy</u>	<u>USAF</u>	<u>USMC</u>
AL	70	56	24	37
AK	4	2	1	1
AZ	50	33	15	25
AR	42	39	18	20
CA	521	413	141	231
CO	68	60	12	31
CT	64	50	17	31
DE	17	8	6	1
DC	15	5	2	2
FL	142	106	58	50
GA	114	78	33	43
HI	28	10	6	8
ID	22	15	7	2
IL	273	155	67	90
IN	145	84	41	47
IA	80	31	22	33
KS	64	15	11	17
KY	74	43	19	32
LA	68	53	23	29
ME	28	10	10	3
MD	80	66	18	43
MA	133	60	38	37
MI	219	152	53	99
MN	102	80	30	46
MS	41	24	14	5

Table B-8 continued

<u>State</u>	<u>Army</u>	<u>Navy</u>	<u>USAF</u>	<u>USMC</u>
MO	140	100	37	78
MT	16	15	6	2
NE	49	31	9	26
NV	15	10	4	1
NH	23	8	7	19
NJ	137	88	34	43
NM	32	19	9	17
NY	354	235	96	140
NC	111	42	30	44
ND	22	11	4	6
OH	261	168	70	112
OK	70	53	20	27
OR	76	76	17	29
PA	243	118	88	139
RI	24	9	8	2
SC	61	33	15	4
SD	20	5	5	5
TN	92	58	27	36
TX	274	195	84	113
UT	28	14	8	2
VT	18	7	4	0*
VA	106	52	28	38
WA	103	66	27	41
WV	49	20	19	25
WI	117	56	25	48
WY	8	5	2	1

* Replaced by 1 for the regression analysis.

Table B-9
Total Unemployment and Unemployment Rates¹ by State: Annual Averages, 1970-75

State	Unemployment (thousands)						Unemployment rate ²					
	1973*	1974	1973	1972	1971	1970	1973*	1974	1973	1972	1971	1970
Alabama.....	128.6	78.0	55.7	63.6	60.0	61.9	5.9	5.5	3.9	4.7	5.2	4.7
Alaska.....	15.8	14.2	13.9	12.9	12.1	9.4	8.6	10.0	10.8	10.5	10.5	8.7
Arizona.....	381.9	49.2	31.0	32.8	28.7	30.7	10.1	5.6	4.1	4.1	4.7	4.4
Arkansas.....	70.2	39.9	33.3	36.1	40.1	36.1	9.0	4.8	4.1	4.6	5.4	5.0
California.....	928.6	608.8	613.0	633.0	730.0	584.0	9.2	7.7	7.0	7.6	8.8	7.2
Colorado.....	133.3	43.4	36.0	35.2	36.7	40.5	9.3	3.8	3.4	3.6	4.0	4.4
Connecticut.....	134.4	87.3	77.3	112.0	120.4	76.4	10.1	6.2	5.7	8.2	8.9	5.6
Delaware.....	12.2	15.1	11.6	11.4	13.3	10.9	9.3	6.0	4.6	4.7	5.7	4.8
District of Columbia ³	27.1	20.0	58.0	42.7	33.5	37.6	8.1	6.0	4.2	3.7	2.7	3.1
Florida.....	334.4	208.0	131.0	125.0	135.0	115.0	11.4	8.2	4.3	4.5	4.9	4.4
Georgia.....	206.0	106.4	61.0	83.0	78.0	78.0	9.6	5.0	3.9	4.1	3.9	4.1
Hawaii.....	26.8	27.3	23.9	24.7	20.6	14.1	7.4	7.6	7.0	7.3	6.3	4.7
Idaho.....	22.2	21.1	19.1	19.9	19.4	17.5	7.4	6.0	5.6	6.2	6.3	5.8
Illinois.....	414.2	223.0	202.0	246.0	241.0	193.0	8.3	4.3	4.1	5.1	5.1	4.1
Indiana.....	208.6	140.2	98.0	103.0	128.0	111.0	8.8	5.9	4.2	5.5	5.7	5.0
Iowa.....	72.0	39.2	37.0	45.1	51.4	44.8	5.7	3.0	2.9	3.6	4.2	3.7
Kansas.....	52.3	36.4	31.5	38.1	51.7	44.6	4.9	3.5	3.1	4.0	5.5	4.8
Kentucky.....	113.4	64.0	58.6	62.5	69.0	61.4	7.7	4.5	4.4	4.8	5.3	5.0
Louisiana.....	117.9	97.0	83.7	84.9	93.8	85.9	8.3	6.7	6.0	6.1	7.0	6.6
Maine.....	44.9	20.3	23.2	29.1	31.3	22.8	10.2	6.7	5.9	7.0	7.6	5.7
Maryland.....	137.5	66.0	60.0	81.0	70.0	53.4	7.5	3.7	3.5	4.7	4.2	3.3
Massachusetts.....	343.7	190.0	171.0	160.0	164.0	113.0	12.5	7.2	6.7	6.4	6.6	4.6
Michigan.....	550.8	338.5	221.0	260.0	271.0	210.8	13.9	8.7	5.8	7.0	7.6	6.7
Minnesota.....	105.4	77.0	79.0	74.0	73.0	68.0	5.9	4.3	4.4	4.3	4.4	4.2
Mississippi.....	72.1	37.6	32.9	33.7	39.1	37.6	4.1	3.6	3.9	4.8	4.8	4.8
Missouri.....	150.6	90.4	73.0	84.0	97.0	63.0	7.3	4.5	3.7	4.2	4.9	3.3
Montana.....	26.6	21.6	19.6	18.5	17.8	15.3	6.0	6.7	6.3	6.2	6.3	5.5
Nebraska.....	40.5	20.6	22.7	22.5	23.5	19.4	5.5	3.8	3.3	3.4	3.6	3.1
Nevada.....	29.0	20.9	15.0	16.9	15.9	12.8	9.7	7.5	6.2	7.0	7.9	5.9
New Hampshire.....	23.7	13.2	12.7	14.4	14.9	10.2	6.9	3.6	3.9	4.5	4.7	3.3
New Jersey.....	326.6	275.1	178.0	182.0	177.0	136.0	10.2	6.9	5.6	5.8	5.7	4.6
New Mexico.....	34.4	26.0	23.5	22.6	23.2	21.0	7.8	6.3	5.7	5.8	6.2	5.9
New York.....	714.3	470.1	405.2	502.0	495.0	330.0	12.1	6.3	5.4	6.7	6.6	4.5
North Carolina.....	229.9	111.0	83.0	93.0	106.0	94.0	9.1	4.5	3.5	4.0	4.8	4.3
North Dakota.....	14.4	13.5	13.3	12.5	13.0	11.0	5.2	3.0	5.1	4.9	5.3	4.6
Ohio.....	405.3	228.3	197.0	251.0	257.0	235.0	8.5	5.0	4.3	5.5	6.5	5.4
Oklahoma.....	72.8	50.0	47.1	48.7	51.2	44.5	6.2	4.4	4.2	4.5	4.9	4.4
Oregon.....	106.9	76.0	52.6	54.4	60.0	54.9	10.2	7.5	5.3	5.7	6.6	6.2
Pennsylvania.....	457.0	258.3	242.2	265.0	261.1	216.9	8.9	5.1	4.8	5.4	5.4	4.5
Puerto Rico.....	157.0	116.0	112.0	111.0	94.7	84.0	18.0	13.2	12.0	12.3	11.6	10.6
Rhode Island.....	65.5	31.3	26.1	27.0	27.2	20.6	14.6	7.3	6.2	6.5	6.8	5.2
South Carolina.....	131.2	56.0	43.9	49.2	57.4	53.6	11.1	4.5	3.7	4.2	5.3	5.0
South Dakota.....	13.9	10.6	9.9	10.7	10.2	8.9	4.9	3.5	3.3	3.7	3.7	3.3
Tennessee.....	157.4	71.8	54.7	62.4	52.3	77.8	8.5	3.9	3.0	3.6	5.0	4.8
Texas.....	324.9	221.0	193.0	220.0	233.0	202.0	6.1	4.3	3.0	4.5	4.9	4.4
Utah.....	38.5	29.4	26.8	27.5	27.6	25.5	7.5	5.9	5.7	6.1	6.4	6.1
Vermont.....	20.7	14.1	11.1	12.7	12.9	9.1	10.0	6.9	5.6	6.5	6.8	4.9
Virginia.....	149.5	66.0	75.0	73.0	69.0	62.0	6.9	4.0	3.6	3.6	3.6	3.4
Washington.....	144.3	108.0	112.3	137.0	142.0	129.0	9.3	7.2	7.1	9.5	10.1	9.1
West Virginia.....	50.6	39.3	37.5	42.5	40.9	37.7	8.2	5.9	5.7	6.5	6.5	6.1
Wisconsin.....	148.1	98.3	84.0	81.0	84.0	72.0	7.0	4.6	4.1	4.2	4.5	3.9
Wyoming.....	8.1	5.9	5.5	5.9	6.4	6.1	4.6	3.6	3.5	4.0	4.5	4.5

* Preliminary (11-month) average.

¹ Revised. Data are not comparable with those published in earlier *Manpower Reports*. For explanation see Note on Historic Comparability of Labor Force Statistics at the beginning of the Statistical Appendix. See also *New Procedures for Estimating Unemployment in States and Local Areas*. Report No. 432, Bureau of Labor Statistics, U.S. Department of Labor.

² Unemployment as percent of labor force.

³ Data relate to the entire SMSA.

SOURCE: State employment security agencies cooperating with the U.S. Department of Labor.

Source: Employment and Training
Report of the President, transmitted
to the Congress, 1976

Table B-10

ESTABLISHMENTS DATA
STATE AND AREA HOURS AND EARNINGS

C-13. Gross hours and earnings of production workers on manufacturing payrolls, by State and selected areas

State and area	Average weekly earnings			Average weekly hours			Average hourly earnings		
	JUNE 1975	MAY 1976	JUNE 1976 ^a	JUNE 1975	MAY 1976	JUNE 1976 ^a	JUNE 1975	MAY 1976	JUNE 1976 ^a
ALABAMA	\$160.34	\$174.90	\$181.22	39.3	40.3	41.0	\$4.08	\$4.34	\$4.42
Birmingham	193.94	219.37	218.90	39.5	40.4	39.8	4.91	5.43	5.50
Mobile	201.20	210.67	224.47	40.0	39.6	40.3	5.03	5.32	5.57
ALASKA	307.05	335.27	(*)	37.4	41.7	(*)	8.21	8.04	(*)
ARIZONA	186.92	202.58	204.73	38.7	39.8	39.6	4.83	5.09	5.17
Phoenix	187.98	202.29	205.65	38.6	39.9	39.7	4.87	5.07	5.19
Tucson	190.12	209.21	211.72	39.2	39.4	39.5	4.85	5.31	5.36
ARKANSAS	138.81	154.77	154.03	39.1	40.2	39.8	3.55	3.85	3.87
Fayetteville-Springdale	130.07	142.04	140.54	39.9	39.9	39.7	3.26	3.56	3.54
Fort Smith	136.52	150.54	154.06	37.2	38.6	39.2	3.67	3.90	3.93
Little Rock-North Little Rock	157.19	175.47	176.51	39.2	39.7	39.4	4.01	4.42	4.48
Pine Bluff	169.60	186.24	200.38	38.9	40.4	41.4	4.36	4.61	4.84
CALIFORNIA	203.97	219.14	223.04	39.3	39.7	39.9	5.19	5.52	5.59
Anaheim-Santa Ana-Garden Grove	191.68	206.63	207.20	40.1	40.2	40.3	4.78	5.14	5.18
Bakersfield	199.56	215.77	210.35	38.9	38.6	37.9	5.13	5.59	5.55
Fresno	176.32	198.35	197.12	38.0	39.2	38.5	4.64	5.06	5.12
Los Angeles-Long Beach	192.57	205.88	209.44	39.3	39.9	40.2	4.90	5.15	5.21
Modesto	192.79	203.63	198.36	38.1	37.5	36.0	5.06	5.43	5.51
Oxnard-Simi Valley-Ventura	182.22	191.00	190.70	39.7	38.9	39.4	4.59	4.91	4.84
Riverside-San Bernardino-Ontario	205.98	229.25	231.95	39.9	39.8	40.2	5.16	5.76	5.77
Sacramento	220.38	233.14	240.95	38.8	38.6	39.5	5.68	6.04	6.10
Salinas-Seaside-Monterey	184.61	195.55	191.01	38.3	38.8	37.6	4.82	5.04	5.08
San Diego	194.43	211.53	213.40	38.5	38.6	38.8	5.05	5.45	5.53
San Francisco-Oakland	239.78	265.44	270.92	38.8	39.5	39.9	6.18	6.72	6.79
San Jose	218.79	246.58	250.04	39.0	39.9	40.2	5.51	5.19	6.22
Santa Barbara-Santa Maria-Lompoc	176.18	188.28	185.93	38.3	38.9	38.1	4.50	4.84	4.88
Santa Rosa	186.50	197.62	209.98	37.3	36.8	38.6	5.00	5.37	5.44
Stockton	218.79	236.02	232.54	39.0	39.6	38.5	5.61	5.96	6.04
Vallejo-Fairfield-Napa	206.45	223.82	228.51	37.4	38.0	38.6	5.52	5.89	5.92
COLORADO	194.24	206.06	212.26	39.4	39.4	40.2	4.93	5.23	5.28
Denver-Boulder	198.97	208.96	211.86	39.4	39.5	39.6	5.05	5.29	5.35
CONNECTICUT	191.68	206.25	208.59	40.1	40.6	40.9	4.78	5.08	5.10
Bridgewater	201.06	218.40	224.27	40.7	42.0	42.8	4.94	5.20	5.24
Hartford	214.56	231.44	233.38	41.5	41.7	41.9	5.17	5.55	5.57
New Britain	199.35	207.25	209.90	40.6	40.4	40.6	4.91	5.13	5.17
New Haven-West Haven	195.02	205.53	207.63	39.8	40.1	40.2	4.90	5.12	5.16
Stamford	199.58	216.11	216.62	40.4	41.8	41.9	4.94	5.17	5.17
Waterbury	164.40	183.84	185.15	40.0	41.5	41.7	4.11	4.43	4.44
DELAWARE	196.50	229.63	230.33	39.3	41.6	41.5	5.00	5.52	5.55
Wilmington	225.22	256.23	257.50	39.1	41.8	41.6	5.76	6.13	6.19
DISTRICT OF COLUMBIA:									
Washington SMSA	217.32	210.21	214.62	38.6	38.5	39.2	5.63	5.46	5.47
FLORIDA	161.19	173.38	173.40	39.8	40.7	40.8	4.05	4.26	4.25
Fort Lauderdale-Hollywood	155.62	169.49	173.29	39.2	39.6	40.3	3.97	4.28	4.37
Jacksonville	202.86	214.11	217.26	42.0	41.9	42.6	4.83	5.11	5.10
Miami	145.78	149.23	150.78	39.4	39.9	40.1	3.70	3.76	3.76
Orlando	163.17	174.58	177.02	41.1	40.6	40.6	3.97	4.30	4.35
Pensacola	194.81	217.33	211.84	41.1	42.2	41.7	4.74	5.15	5.08
Tampa-St. Petersburg	178.49	182.61	188.78	40.2	40.4	41.4	4.64	4.52	4.56
West Palm Beach-Boca Raton	191.02	204.67	209.10	40.3	41.9	42.5	4.74	4.88	4.92
GEORGIA	151.26	167.64	169.72	39.7	40.6	40.7	3.81	4.13	4.17
Atlanta	179.54	210.08	209.87	39.2	40.4	39.9	4.58	5.20	5.26
Savannah	191.78	216.72	226.37	41.6	43.0	43.2	4.61	5.04	5.24
HAWAII	175.28	193.55	192.27	39.3	38.1	39.4	4.66	5.08	4.88
Honolulu	170.61	181.42	183.35	38.6	36.9	39.3	4.42	4.93	4.75
IDAHO	181.12	194.30	207.11	38.7	38.4	39.7	4.68	5.06	5.27

See footnotes at end of table.

Table B-10 continued

ESTABLISHMENT DATA
STATE AND AREA HOURS AND EARNINGS

C-13. Gross hours and earnings of production workers on manufacturing payrolls, by State and selected areas—Continued

State and area	Average weekly earnings			Average weekly hours			Average hourly earnings		
	JUNE 1975	MAY 1976	JUNE 1976P	JUNE 1975	MAY 1976	JUNE 1976P	JUNE 1975	MAY 1976	JUNE 1976P
ILLINOIS	1212.66	1233.29	(*)	39.6	40.5	(*)	35.38	35.77	(*)
INDIANA	216.37	243.95	245.78	39.7	41.0	41.1	5.45	5.95	5.98
Indianapolis	216.68	242.18	(*)	40.2	41.9	(*)	5.39	5.78	(*)
IOWA	213.15	231.20	232.18	39.4	40.0	40.1	5.41	5.79	5.79
Cedar Rapids	214.09	236.43	252.76	39.5	40.7	41.3	5.42	5.76	6.12
Des Moines	216.98	238.16	238.76	39.0	39.3	39.4	5.71	6.06	6.06
Dubuque	246.65	274.13	278.00	38.6	39.5	40.0	6.39	6.94	6.95
Sioux City	188.16	212.70	207.09	39.2	39.1	39.0	4.80	5.44	5.31
Waterloo—Cedar Falls	265.95	284.97	283.29	39.4	39.8	39.4	6.75	7.16	7.19
KANSAS	186.42	200.28	202.91	40.6	40.8	41.3	4.59	4.91	4.91
Topeka	190.02	193.74	190.80	40.2	40.3	41.7	4.73	4.56	4.65
Wichita	211.34	219.72	219.64	41.7	41.3	41.4	5.07	5.32	5.31
KENTUCKY	176.93	199.40	200.09	38.8	39.8	39.7	4.56	5.01	5.04
Louisville	212.22	232.80	236.16	39.3	40.0	40.3	5.40	5.82	5.85
LOUISIANA	194.14	217.24	223.13	40.7	41.3	42.1	4.77	5.26	5.30
Baton Rouge	245.86	276.87	282.01	42.1	42.4	42.6	5.94	6.53	6.52
New Orleans	185.10	205.25	216.52	39.3	39.7	41.4	4.71	5.17	5.23
Shreveport	180.09	185.78	196.30	41.4	40.3	41.5	4.35	4.61	4.73
MAINE	150.88	160.40	163.60	39.6	39.9	40.0	3.81	4.02	4.09
Lewiston—Auburn	127.38	140.30	140.66	38.6	39.3	39.4	3.30	3.57	3.57
Portland	160.37	169.62	173.75	39.5	40.1	40.5	4.06	4.23	4.29
MARYLAND	197.39	218.80	219.60	39.4	40.0	40.0	5.01	5.47	5.49
Baltimore	206.71	228.17	232.30	39.6	40.1	40.4	5.22	5.69	5.75
MASSACHUSETTS	173.21	188.47	188.87	39.1	40.1	40.1	4.43	4.70	4.71
Boston	191.18	207.63	209.27	39.5	40.2	40.4	4.84	5.16	5.18
Brockton	145.54	152.85	154.80	38.4	38.5	38.7	3.79	3.97	4.00
Fall River	124.96	137.90	138.90	35.5	36.1	35.8	3.52	3.82	3.88
Lawrence—Haverhill	167.42	181.94	181.37	39.3	39.9	39.6	4.26	4.56	4.58
Lowell	165.95	168.13	169.38	39.7	39.1	39.3	4.18	4.30	4.31
New Bedford	148.60	159.80	161.46	38.2	38.6	39.0	3.89	4.14	4.14
Springfield—Chicopee—Holyoke	173.05	188.73	190.01	39.6	40.5	40.6	4.37	4.66	4.68
Worcester	174.47	189.21	188.02	38.6	39.5	39.5	4.52	4.79	4.75
MICHIGAN	245.19	292.61	300.80	40.3	43.1	43.9	6.08	6.79	6.85
Ann Arbor	258.77	331.94	342.16	40.3	45.1	45.3	6.42	7.36	7.39
Battle Creek	266.75	282.51	282.57	42.1	41.4	41.5	6.34	6.82	6.81
Bay City	265.59	306.79	309.05	44.6	47.3	47.4	5.96	6.49	6.52
Detroit	259.77	311.24	321.35	40.1	43.5	44.7	6.68	7.16	7.19
Flint	274.40	353.35	357.35	40.4	47.0	47.1	6.80	7.52	7.59
Grand Rapids	203.95	224.26	227.93	39.5	40.4	40.5	5.16	5.55	5.63
Jackson	227.22	242.58	241.74	41.0	40.9	40.5	5.34	5.93	5.97
Kalamazoo—Portage	221.97	254.89	256.76	40.3	41.5	41.6	5.51	6.14	6.17
Lansing—East Lansing	246.48	332.05	323.73	40.2	45.8	44.9	6.18	7.25	7.21
Muskegon—Norton Shores—Muskegon Heights	217.69	248.66	248.11	40.5	41.7	41.4	5.38	5.96	5.99
Saginaw	281.52	346.47	348.50	40.7	44.7	44.6	6.92	7.75	7.81
MINNESOTA	198.86	214.49	215.28	39.3	39.5	39.5	5.06	5.43	5.45
Duluth—Superior	183.38	194.89	197.18	39.1	38.9	39.2	4.69	5.01	5.03
Minneapolis—St. Paul	212.40	228.10	230.26	39.7	39.6	39.7	5.35	5.75	5.80
MISSISSIPPI	140.54	150.84	152.76	39.7	39.8	40.2	3.54	3.79	3.80
Jackson	151.11	153.58	156.78	41.4	40.1	40.2	3.65	3.83	3.90
MISSOURI	187.07	204.00	205.31	39.3	40.0	40.1	4.76	5.10	5.12
Kansas City	209.47	237.39	240.12	39.3	41.0	41.4	5.33	5.79	5.80
St. Joseph	184.13	190.80	196.50	41.1	40.0	40.6	4.48	4.77	4.84
St. Louis	216.22	233.02	236.45	39.6	39.9	39.9	5.46	5.84	5.93
Springfield	159.44	174.99	177.06	38.7	39.5	39.7	4.12	4.43	4.45
MONTANA	189.74	231.45	230.68	36.7	39.7	39.5	5.17	5.83	5.84

See footnotes at end of table.

Table B-10 continued

ESTABLISHMENT DATA
STATE AND AREA HOURS AND EARNINGS

C-13. Gross hours and earnings of production workers on manufacturing payrolls, by State and selected areas—Continued

State and area	Average weekly earnings			Average weekly hours			Average hourly earnings		
	JUNE 1975	MAY 1976	JUNE 1976P	JUNF 1975	MAY 1976	JUNE 1976P	JUNE 1975	MAY 1975	JUNE 1976P
NEBRASKA	\$181.96	\$207.16	\$208.47	41.0	41.6	42.7	\$4.44	\$4.98	\$4.89
Lincoln	159.81	180.15	184.27	37.8	39.6	39.4	4.22	4.55	4.67
Omaha	199.21	223.47	228.80	40.9	42.0	42.5	4.87	5.32	5.38
NEVADA	200.26	204.75	219.06	38.0	37.5	39.4	5.27	5.46	5.56
Las Vegas	246.87	260.17	(*)	39.0	39.6	(*)	6.33	6.57	(*)
NEW HAMPSHIRE	154.06	165.57	166.76	39.3	39.8	39.8	3.92	4.16	4.19
Manchester	142.40	153.66	151.71	38.8	39.5	38.8	3.67	3.89	3.91
Nashua	175.08	182.40	184.80	39.7	40.0	40.0	4.41	4.56	4.56
NEW JERSEY	197.96	220.18	221.01	40.4	41.7	41.7	4.90	5.28	5.30
Atlantic City	146.43	160.01	162.80	35.2	36.7	37.0	4.16	4.36	4.40
Camden	180.42	196.71	197.51	38.8	39.9	39.9	4.65	4.93	4.95
Hackensack	190.87	204.22	204.11	39.6	40.2	40.1	4.82	5.08	5.09
Jersey City	190.55	203.31	206.40	40.2	40.1	40.0	4.74	5.07	5.16
New Brunswick—Perth Amboy—Sayreville ⁴	211.87	231.90	232.22	39.9	40.9	41.1	5.31	5.67	5.65
Newark ⁴	205.18	229.52	229.30	41.2	42.9	42.7	4.98	5.35	5.37
Pearson—Clifton—Passaic ⁴	192.10	208.38	207.40	40.7	42.7	42.5	4.72	4.89	4.89
Trenton	213.70	245.40	247.34	42.4	44.7	45.3	5.04	5.40	5.46
NEW MEXICO	144.67	158.77	156.02	39.1	40.4	39.8	3.70	3.93	3.92
Albuquerque	151.30	160.34	156.42	39.4	40.8	39.7	3.84	3.93	3.94
NEW YORK	190.12	206.98	207.38	38.8	39.5	39.5	4.90	5.24	5.25
Albany—Schenectady—Troy	198.18	223.02	223.31	39.4	41.3	40.9	5.03	5.40	5.46
Binghamton	185.09	196.65	193.05	40.5	41.4	40.9	4.57	4.75	4.72
Buffalo	230.10	266.80	272.54	39.2	41.3	41.8	5.87	6.46	6.52
Elmira	184.93	202.40	200.15	39.6	40.0	39.4	4.67	5.06	5.08
Monroe County ⁵	237.69	270.28	264.38	40.7	42.1	41.7	5.84	6.42	6.34
Nassau—Suffolk ⁴	187.46	195.42	196.02	39.3	39.4	39.6	4.77	4.96	4.95
New York—Northeastern New Jersey	187.20	201.17	(*)	39.0	39.6	(*)	4.80	5.08	(*)
New York and Nassau—Suffolk ⁴	176.90	186.47	186.96	37.8	37.9	38.0	4.68	4.92	4.92
New York SMSA ⁴	175.13	184.99	185.48	37.5	37.6	37.7	4.67	4.92	4.92
New York City	173.72	182.77	183.26	37.2	37.3	37.4	4.67	4.90	4.90
Poughkeepsie	194.00	217.87	215.87	38.8	40.8	40.5	5.00	5.34	5.33
Rochester	228.83	257.49	251.52	40.5	41.8	41.3	5.65	6.16	6.09
Rockland County ⁷	188.37	207.90	211.08	41.4	42.0	42.3	4.55	4.95	4.99
Syracuse	205.44	224.95	224.41	40.6	41.2	41.1	5.06	5.46	5.45
Utica—Rome	170.21	187.53	190.40	39.4	39.9	40.0	4.32	4.70	4.76
Weschester County ⁷	183.53	199.87	200.09	39.3	39.5	39.7	4.67	5.06	5.04
NORTH CAROLINA	134.59	147.66	148.83	38.9	39.8	39.9	3.46	3.71	3.73
Asheville	133.72	146.03	147.97	39.1	39.9	40.1	3.62	3.66	3.69
Charlotte—Gastonia	133.08	152.07	152.03	38.8	41.1	41.2	3.43	3.70	3.69
Greensboro—Winston-Salem—High Point	147.06	158.79	160.38	38.7	39.3	39.5	3.80	4.02	4.05
Raleigh—Durham	150.93	161.85	162.24	38.6	39.0	39.0	3.91	4.15	4.15
NORTH DAKOTA	169.62	187.93	191.35	40.1	39.9	40.2	4.23	4.71	4.76
Fargo—Moorhead	182.51	202.19	203.77	40.2	40.6	41.0	4.54	4.98	4.97
OHIO	220.95	250.43	252.89	40.1	41.5	41.8	5.51	6.02	6.05
Akron	235.00	242.60	240.85	41.3	41.4	41.1	5.69	5.86	5.85
Canton	220.81	244.95	244.84	39.5	39.7	39.3	5.59	6.17	6.23
Cleveland	209.20	231.54	234.89	40.7	41.2	41.5	5.14	5.62	5.66
Columbus	224.80	259.30	263.30	40.0	42.3	42.4	5.62	6.13	6.21
Dayton	207.63	226.24	230.04	39.7	40.4	40.5	5.23	5.60	5.68
Toledo	232.47	268.27	264.31	41.0	43.2	42.7	5.67	6.21	6.19
Youngstown—Warren	234.03	259.79	259.79	40.7	41.7	41.7	5.75	6.23	6.23
243.42	276.80	278.80	38.7	40.0	40.0	6.29	6.92	6.97	
OKLAHOMA	174.32	187.13	190.35	39.8	39.9	40.5	4.38	4.69	4.70
Oklahoma City	175.96	192.23	190.95	39.9	40.3	40.2	4.41	4.77	4.75
Tulsa	189.77	210.49	208.55	39.7	40.4	39.8	4.78	5.21	5.24
OREGON	221.05	233.63	245.52	39.9	39.2	39.6	5.54	5.96	6.20
Eugene—Springfield	237.02	246.58	269.04	42.1	39.9	41.2	5.63	6.18	5.53
Jackson County	234.77	237.34	264.58	41.7	39.1	42.4	5.63	6.07	6.24
Portland	209.21	232.46	232.54	37.9	39.2	38.5	5.52	5.93	5.94

See footnotes at end of table.

Table B-10 continued

ESTABLISHMENT DATA
STATE AND AREA HOURS AND EARNINGS

C-13. Gross hours and earnings of production workers on manufacturing payrolls, by State and selected areas—Continued

State and area	Average weekly earnings			Average weekly hours			Average hourly earnings		
	JUNF 1975	MAY 1976	JUNE 1976P	JUNF 1975	MAY 1976	JUNE 1976P	JUNF 1975	MAY 1976	JUNE 1976P
PENNSYLVANIA	\$188.54	\$207.76	\$208.94	38.4	39.2	39.2	\$4.91	\$5.30	\$5.33
Allentown-Bethlehem-Easton	188.98	199.54	201.22	38.1	38.3	38.4	4.96	5.21	5.26
Altoona	159.09	173.25	171.77	37.7	38.5	38.6	4.22	4.50	4.45
Delaware Valley ¹	198.27	221.45	220.73	38.8	39.9	39.7	5.11	5.55	5.56
Erie	203.77	210.60	208.64	41.0	40.5	40.2	4.97	5.20	5.19
Harrisburg	175.87	188.64	189.21	39.7	39.3	39.5	4.43	4.80	4.79
Johnstown	206.65	225.38	228.82	37.1	37.5	38.2	5.57	6.01	5.99
Lancaster	169.26	191.63	190.76	39.0	40.6	40.5	4.34	4.72	4.71
Northeast Pennsylvania	139.59	147.60	148.99	35.7	36.0	35.9	3.91	4.10	4.15
Philadelphia SMSA	196.33	218.25	217.56	38.8	39.9	39.7	5.06	5.47	5.48
Pittsburgh	225.03	254.29	255.91	39.0	40.3	40.3	5.77	6.31	6.35
Reading	172.77	187.46	187.77	39.0	39.3	39.2	4.43	4.77	4.79
Scranton ²	140.79	145.20	148.83	36.1	35.5	36.3	3.90	4.09	4.10
Wilkes-Barre-Hazleton ¹⁰	137.42	148.42	148.10	35.6	36.2	35.6	3.86	4.10	4.16
Williamsport	172.48	176.15	175.38	39.2	38.8	38.8	4.60	4.54	4.52
York	175.74	191.47	193.64	40.4	41.0	41.2	4.35	4.67	4.70
RHODE ISLAND	148.22	162.35	165.19	38.7	39.5	39.9	3.83	4.11	4.14
Providence-Warwick-Pawtucket	148.22	164.81	166.43	38.7	40.1	40.2	3.83	4.11	4.14
SOUTH CAROLINA ¹	140.54	153.12	155.07	39.7	40.4	40.7	3.54	3.79	3.81
Charleston-North Charleston ¹	160.00	173.66	173.72	40.2	40.2	40.4	3.98	4.32	4.30
Columbia ¹	141.74	151.70	153.26	38.0	39.2	39.5	3.73	3.87	3.88
Greenville-Spartburg	141.91	155.42	155.04	40.2	40.9	40.8	3.53	3.80	3.80
SOUTH DAKOTA	177.66	179.34	183.72	42.4	40.3	41.1	4.19	4.45	4.47
Sioux Falls	225.62	226.59	236.56	44.5	41.5	42.7	5.07	5.46	5.56
TENNESSEE	157.16	168.92	172.63	40.5	40.9	41.2	3.89	4.13	4.19
Chattanooga	170.54	178.70	185.59	40.8	40.8	41.8	4.18	4.38	4.44
Knoxville	178.35	202.45	206.59	39.9	41.4	41.4	4.47	4.89	4.99
Memphis	185.66	185.33	194.00	40.1	39.5	40.5	4.53	4.65	4.79
Nashville-Davidson	162.74	176.62	176.71	39.5	39.6	39.8	4.12	4.46	4.46
TEXAS	185.64	199.67	203.12	40.8	41.0	41.2	4.55	4.87	4.93
Amarillo	155.20	178.36	178.09	38.8	39.2	39.4	4.00	4.55	4.52
Austin	153.71	168.92	172.08	41.1	41.0	40.3	3.74	4.12	4.27
Beaumont-Port Arthur-Orange	235.73	272.00	275.65	38.9	40.0	40.3	6.06	5.80	5.84
Corpus Christi	202.57	210.76	206.93	43.1	38.6	37.9	4.70	5.46	5.46
Dallas-Fort Worth	175.82	183.82	186.00	40.7	40.4	40.7	4.32	4.55	4.57
El Paso	130.42	143.05	148.06	38.7	39.3	39.8	3.37	3.64	3.72
Galveston-Texas City	291.50	328.71	328.26	44.1	44.3	44.3	6.61	7.42	7.41
Houston	222.50	243.76	248.22	42.3	42.1	42.0	5.25	5.73	5.91
Lubbock	150.73	150.12	150.59	42.7	41.7	41.6	3.53	3.60	3.62
San Antonio	140.35	151.37	153.00	40.1	40.8	40.9	3.50	3.71	3.75
Waco	154.31	173.13	174.93	40.5	39.8	40.4	3.81	4.35	4.33
Wichita Falls	165.57	173.84	175.22	41.6	39.6	39.2	3.98	4.39	4.47
UTAH	153.54	160.22	158.65	38.1	38.7	38.8	4.03	4.14	4.11
Salt Lake City-Ogden	153.58	159.12	160.31	38.3	39.0	39.1	4.01	4.08	4.10
VERMONT	165.65	175.82	177.92	40.5	40.7	40.9	4.09	4.32	4.35
Burlington	184.91	207.83	207.27	41.0	42.5	42.3	4.51	4.89	4.90
Springfield	187.37	188.00	186.59	41.0	40.0	39.7	4.57	4.70	4.70
VIRGINIA	156.81	170.45	171.65	39.4	40.2	40.2	3.98	4.24	4.27
Lynchburg	152.87	180.18	170.34	39.4	40.4	39.8	3.88	4.46	4.28
Norfolk-Virginia Beach-Portsmouth	160.80	185.56	187.32	40.2	41.7	42.0	4.00	4.45	4.45
Northern Virginia ¹¹	198.18	185.94	186.58	39.4	38.9	38.0	5.03	4.78	4.91
Richmond	180.32	205.00	202.31	39.2	41.0	40.3	4.50	5.00	5.02
Roanoke	141.21	151.69	148.58	38.9	39.4	39.1	3.63	3.85	3.80
WASHINGTON	223.86	244.95	248.77	39.0	39.7	39.3	5.74	6.17	6.33
Seattle-Everett	231.67	253.04	253.62	39.4	39.6	39.2	5.88	6.39	6.47
Spokane	192.62	218.01	219.18	36.9	39.0	39.0	5.22	5.59	5.62
Tacoma	230.44	247.68	246.91	39.8	38.7	38.7	5.79	6.40	6.38
WEST VIRGINIA	189.83	213.33	213.05	38.9	40.1	39.6	4.88	5.32	5.38
Charleston	227.01	243.72	244.96	41.2	41.1	41.1	5.51	5.93	5.95
Huntington-Ashland	209.41	238.79	239.38	37.8	40.2	40.3	5.54	5.94	5.94
Parkersburg-Marietta	206.58	232.15	235.91	39.2	40.8	41.1	5.27	5.69	5.74

See footnotes at end of table.

Table B-10 continued

ESTABLISHMENT DATA
STATE AND AREA HOURS AND EARNINGS

C-13. Gross hours and earning of production workers on manufacturing payrolls, by State and selected areas—Continued

State and area	Average weekly earnings			Average weekly hours			Average hourly earnings		
	JUNE 1975	MAY 1976	JUNE 1976P	JUNE 1975	MAY 1976	JUNE 1976P	JUNE 1975	MAY 1975	JUNE 1976P
WEST VIRGINIA—Continued									
Wheeling	\$205.32	\$219.54	\$217.80	40.9	39.7	39.6	\$5.02	\$5.53	\$5.50
WISCONSIN									
Appleton-Oshkosh	210.86	228.77	227.66	40.2	40.6	40.3	5.25	5.63	5.64
Green Bay	199.98	217.84	222.30	40.7	41.1	41.4	5.32	5.33	5.37
Kenosha	218.39	228.25	232.27	41.7	41.0	41.7	5.23	5.56	5.56
La Crosse	286.66	260.61	255.93	43.3	39.2	38.4	6.62	6.65	6.66
Madison	189.80	198.95	199.90	42.1	41.8	40.5	4.51	4.77	4.69
Milwaukee	234.77	248.47	245.32	40.2	40.3	39.7	5.85	6.17	6.18
Racine	229.61	249.85	248.40	40.0	40.4	40.0	5.74	6.18	6.21
WYOMING	223.79	240.69	236.75	39.4	40.0	39.7	5.69	6.02	5.95
Casper	195.17	228.08	222.27	38.7	41.3	40.6	5.04	5.52	5.48
Cheyenne	223.45	251.17	250.80	36.4	42.2	39.7	6.14	5.95	6.31
	185.07	270.81	233.64	31.0	33.0	29.9	5.97	8.20	7.81

¹ Based on 1972 Standard Industrial Classification.² Initial publication in this table.³ Subarea of Philadelphia, Pennsylvania Standard Metropolitan Statistical Area: Burlington, Camden, and Gloucester Counties, New Jersey.⁴ Subarea of New York—Northeastern New Jersey.⁵ Subarea of Rochester Standard Metropolitan Statistical Area.⁶ Area included in New York and Nassau—Suffolk combined SMSA's.⁷ Subarea of New York Standard Metropolitan Statistical Area.⁸ Subarea of Philadelphia, Pennsylvania Standard Metropolitan Statistical Area: Bucks, Chester, Delaware, Montgomery, and Philadelphia Counties, Pennsylvania.⁹ Subarea of Northeast Pennsylvania Standard Metropolitan Statistical Area: Lackawanna County.¹⁰ Subarea of Northeast Pennsylvania Standard Metropolitan Statistical Area: Luzerne County.¹¹ Subarea of Washington, D.C. Standard Metropolitan Statistical Area: Alexandria, Fairfax, Falls Church, Manassas, and Manassas Park cities, and Arlington, Fairfax, Loudoun, and Prince William Counties, Virginia.

* Preliminary.

* Not available.

SOURCE: Cooperating State agencies listed on inside back cover.

APPENDIX C

CORRELATION MATRICES, MEANS AND STANDARD DEVIATIONS
OF VARIABLES USED IN THE SUPPLY MODELS

APPENDIX C

In this appendix, the following generic labels are used with reference to the model under consideration, viz.

N_W : white I-IIIA, DHSG, 17-21-year-old male accessions;

N_B : non-white I-IIIA, DHSG, 17-21-year-old, male accessions;

N_T : total I-IIIA, DHSG, 17-21-year-old, male accessions;

Q_W : white, I-IIIA, DHSG, 17-21-year-old, males who are not currently in school;

Q_B : non-white, I-IIIA, DHSG, 17-21-year-old males who are not currently in school;

Q_T : total, I-IIIA, DHSG, 17-21-year-old, males who are not currently in school;

R : recruiters assigned at station level;

U : general unemployment rate;

E : the index of civilian wage computed as the reciprocal of average manufacturing wage.

N_W , N_B , N_T , and R are specific to the service under consideration while Q_W , Q_B , Q_T , U and E are service-independent.

Table C-1
Army White Supply Model Correlations

	N _W	Q _W	R	U	E
N _W	1.0	.95	.96	.26	-.23
Q _W		1.0	.94	.19	-.37
R			1.0	.21	-.25
U				1.0	.08
E					1.0

Table C-2
Army Non-white Supply Model Correlations

	N _B	Q _B	R	U	E
N _B	1.0	.60	.59	.20	.26
Q _B		1.0	.88	.22	-.21
R			1.0	.21	-.25
U				1.0	.08
E					1.0

Table C-3
Army Total Supply Model Correlations

	N _T	Q _T	R	U	E
N _T	1.0	.92	.96	.27	-.16
Q _T		1.0	.95	.19	-.36
R			1.0	.21	-.25
U				1.0	.08
E					1.0

Table C-4
Means and Standard Deviations for Army Supply Variables

Variable	Mean	Standard Deviation
N _W	938.216	936.253
N _B	159.725	200.375
N _T	1097.94	1060.72
Q _W	12695.3	13464.0
Q _B	547.176	744.086
Q _T	13242.5	14075.3
R	96.333	98.835
U	8.41	2.136
E	.0055	.00087

Table C-5

Navy White Supply Model Correlations

	N _W	Q _W	R	U	E
N _W	1.0	.94	.97	.23	-.27
Q _W		1.0	.89	.19	-.37
R			1.0	.21	-.26
U				1.0	.08
E					1.0

Table C-6

Navy Non-white Supply Model Correlations

	N _B	Q _B	R	U	E
N _B	1.0	.87	.93	.19	-.12
Q _B		1.0	.86	.22	-.21
R			1.0	.21	-.26
U				1.0	.08
E					1.0

Table C-7

Navy Total Supply Model Correlations

	N _T	Q _T	R	U	E
Q _T	1.0	.94	.97	.23	-.26
R		1.0	.90	.19	-.36
U			1.0	.21	-.26
E				1.0	.08
					1.0

Table C-8

Means and Standard Deviations for Navy Supply Variables

<u>Variable</u>	<u>Mean</u>	<u>Standard Deviation</u>
N _W	943.745	1006.90
N _B	80.7451	92.6871
N _T	1024.49	1092.23
Q _W	12695.3	13464.0
Q _B	547.176	744.086
Q _T	13242.5	14075.3
R	61.608	71.728
U	8.41	2.14
E	.0055	.00087

Table C-9

USAF White Supply Model Correlations

	N _W	Q _W	R	U	E
N _W	1.0	.93	.97	.28	-.24
Q _W		1.0	.93	.19	-.37
R			1.0	.23	-.20
U				1.0	.08
E					1.0

Table C-10

USAF Non-white Supply Model Correlations

	N _B	Q _T	R	U	E
N _B	1.0	.90	.85	.22	-.04
Q _B		1.0	.86	.22	-.21
R			1.0	.23	-.20
U				1.0	.08
E					1.0

Table C-11

USAF Total Supply Model Correlations

	N _T	Q _T	R	U	E
N _T	1.0	.93	.97	.27	-.22
Q _T		1.0	.94	.19	-.36
R			1.0	.23	-.20
U				1.0	.08
E					1.0

Table C-12

Means and Standard Deviations for USAF Supply Variables

<u>Variable</u>	<u>Mean</u>	<u>Standard Deviation</u>
N _W	781.000	802.627
N _B	85.9804	101.717
N _T	866.980	886.234
Q _W	12695.3	13464.0
Q _B	547.176	744.086
Q _T	13242.5	14075.3
R	26.843	27.880
U	8.41	2.14
E	.0055	.00087

Table C-13

USMC White Supply Model Correlations

	N _W	Q _W	R	U	E
N _W	1.0	.97	.96	.19	-.35
Q _W		1.0	.94	.19	-.37
R			1.0	.16	-.27
U				1.0	.08
E					1.0

Table C-14

USMC Non-white Supply Model Correlations

	N _B	Q _B	R	U	E
N _B	1.0	.86	.81	.20	-.08
Q _B		1.0	.87	.22	-.21
R			1.0	.16	-.27
U				1.0	.08
E					1.0

Table C-15

USMC Total Supply Model Correlations

	N _T	Q _T	R	U	E
N _T	1.0	.97	.97	.20	-.31
Q _T		1.0	.95	.19	-.36
R			1.0	.16	-.27
U				1.0	.08
E					1.0

Table C-16

Means and Standard Deviations for USMC Supply Models

<u>Variable</u>	<u>Mean</u>	<u>Standard Deviation</u>
N _W	371.765	394.738
N _B	63.4118	76.7609
N _T	435.176	455.957
Q _W	12695.3	13464.0
Q _B	547.176	744.086
Q _T	13242.5	14075.3
R	38.471	44.233
U	8.41	2.14
E	.0055	.00087

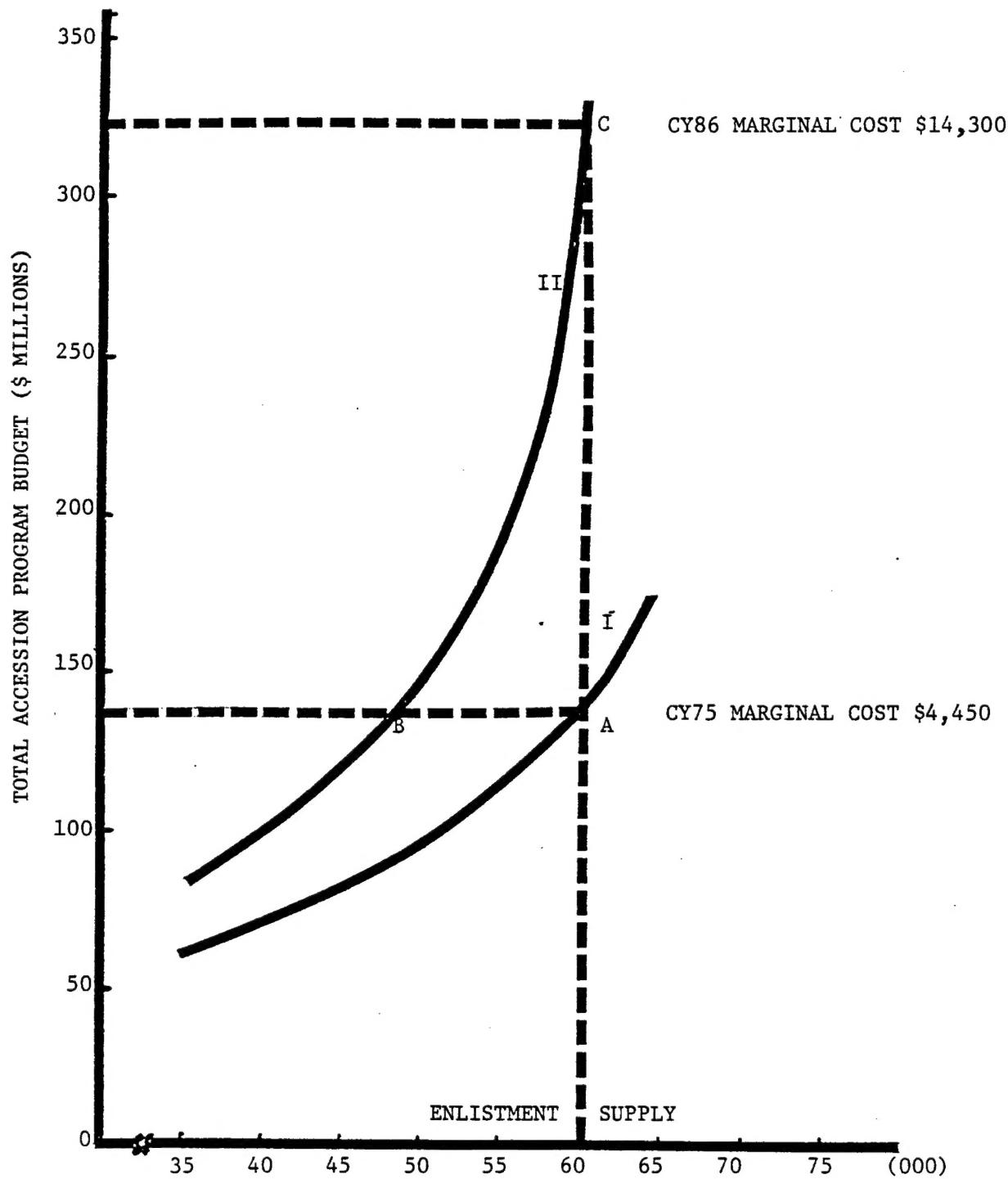


Fig. 6.2—Army Accession Production Functions
NPS Male, DHSG, I-IIIa

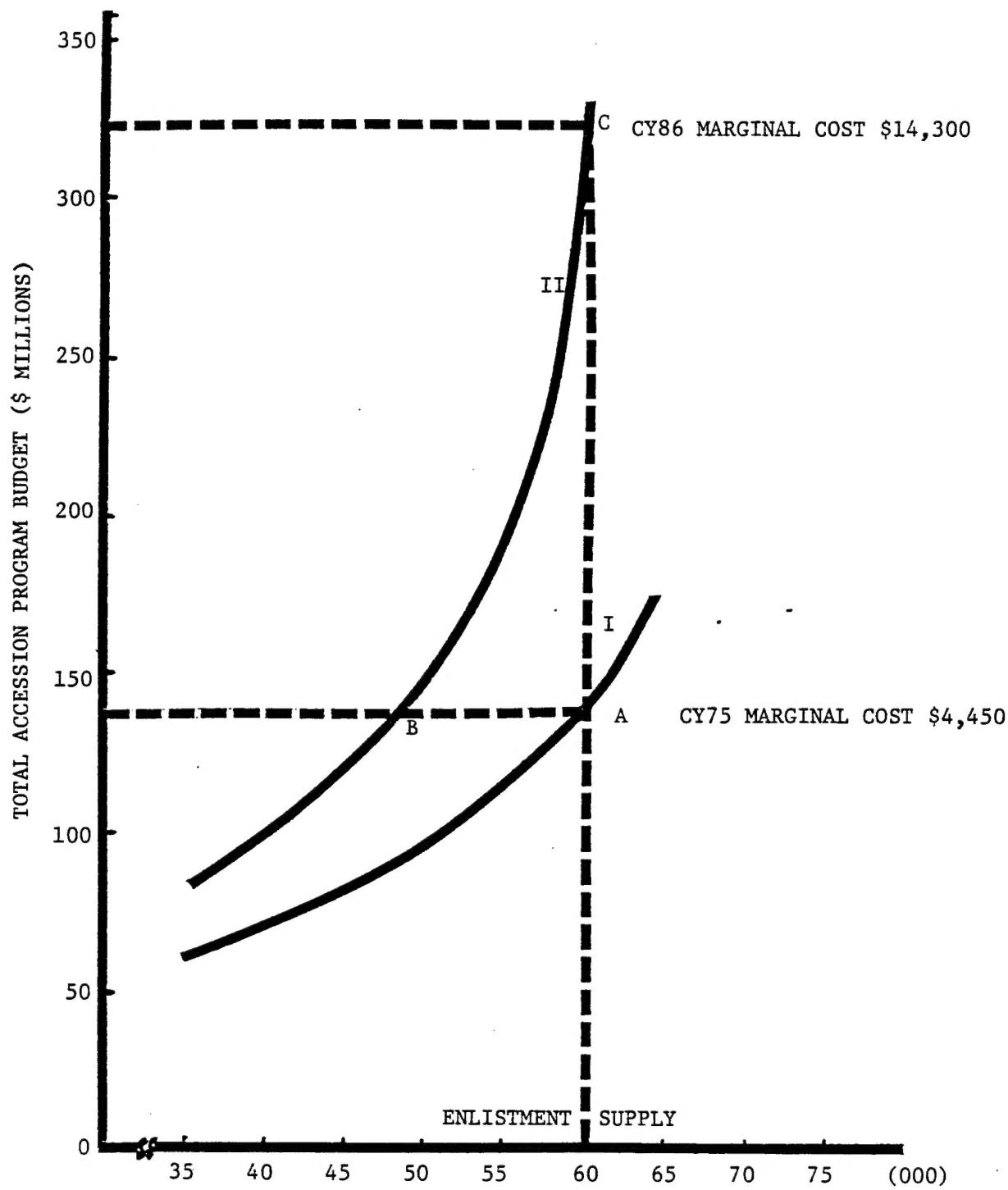


Fig. 1.3—Army Accession Production Functions
NPS Male, DHSG, I-IIIA

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